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The Selection of Tin for Fabrication

C. L. MANTELL

An X-Ray Study of the A_3 Point of Iron and Some Iron-Nickel Alloys

OSCAR L. ROBERTS and WHEELER P. DAVEY

New Etching Reagent for the Macrography of Aluminum and Its Alloys

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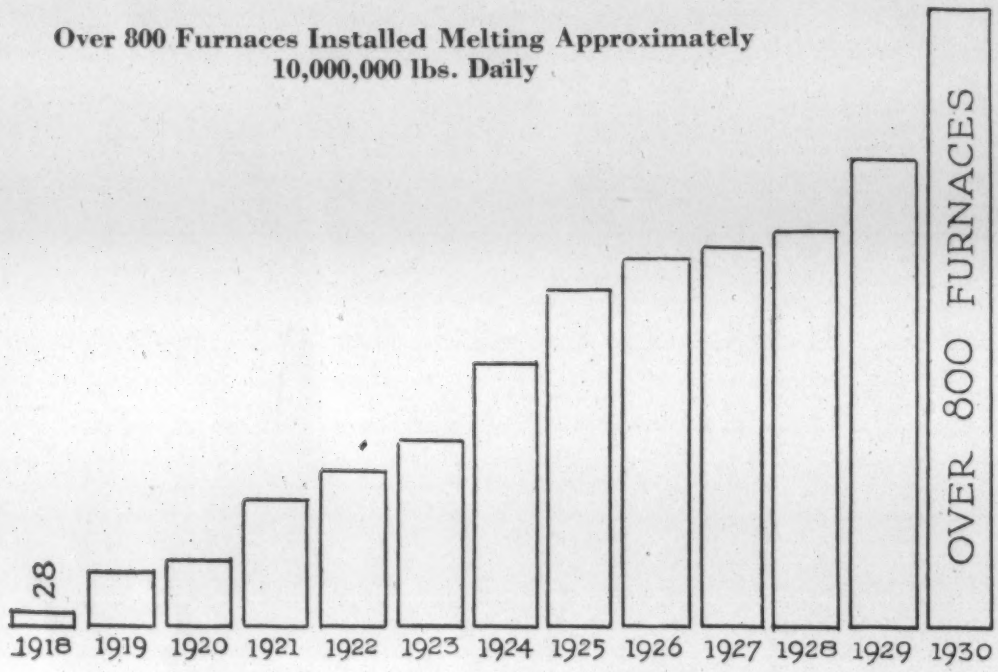

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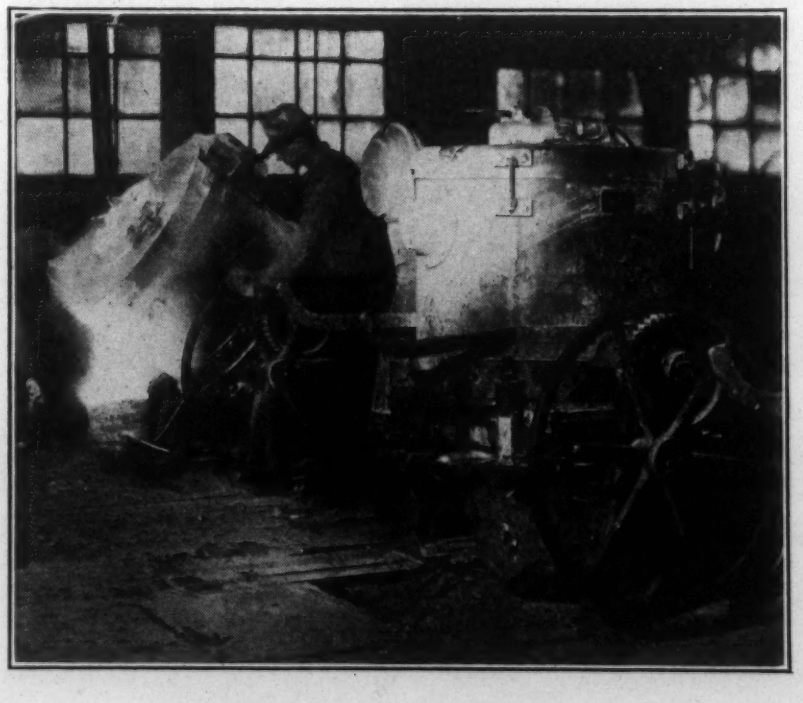

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417 Fourth Avenue New York, U. S. A.

PUBLISHER'S PAGE

Note—On this page the publishers will talk right straight to you each month We will tell you how things are progressing with METALS & ALLOYS *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

We are using this page this month to quote the following timely and interesting editorial from the New York Herald Tribune for Monday, August 4th, feeling that it might not otherwise come to the attention of many of our readers who do not regularly see the New York papers.

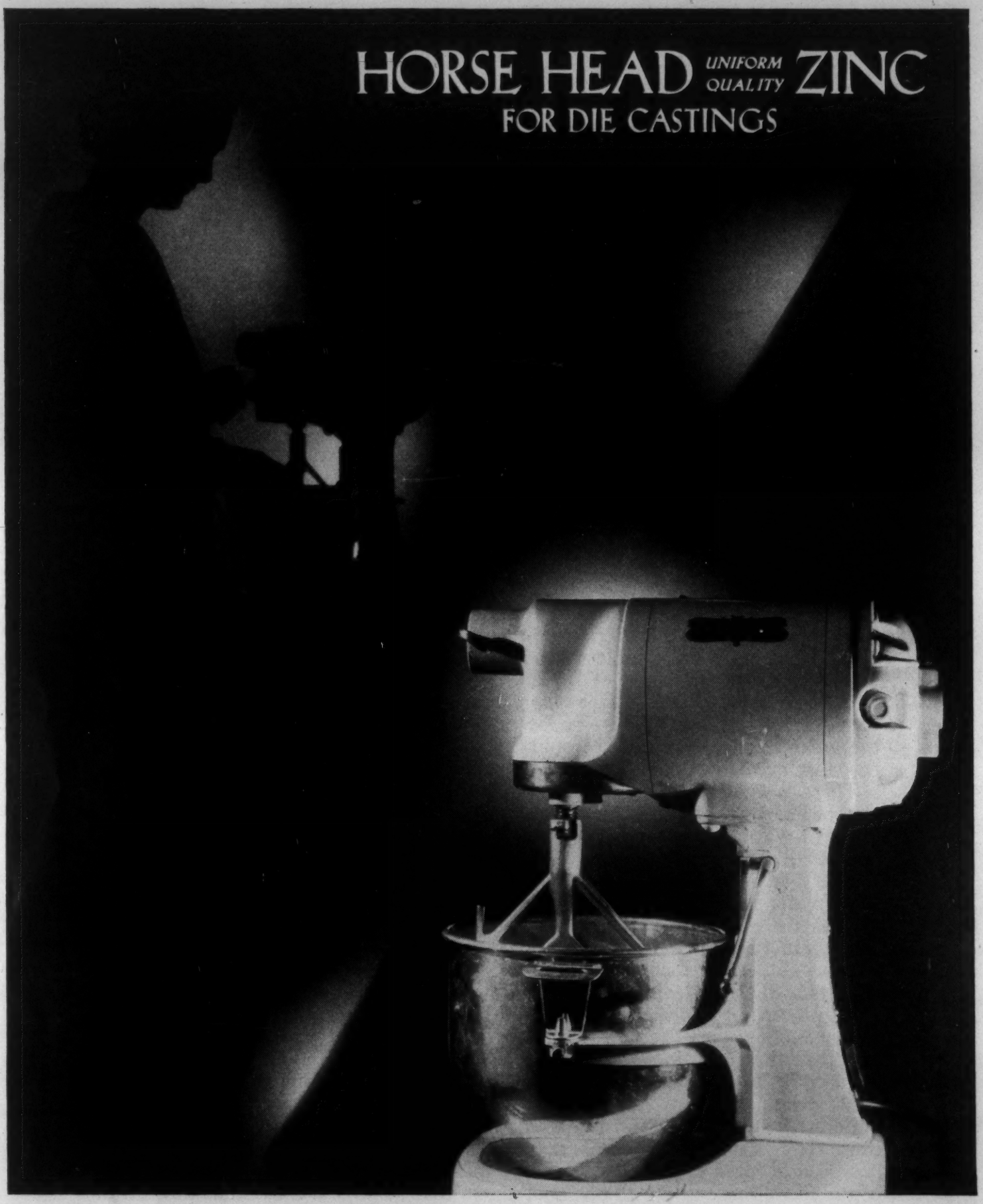
Metals for Dirigibles

Comments on their successful voyage by the commander, designer and crew of the R-100 again emphasize the fact that the dirigible of the future—if this type of aircraft is to have a future—must be constructed first of all under the microscopes of the metallurgists. For practicable trans-Atlantic navigation in such ships, the officers and crew are reported to have decided, it will be necessary to have still larger craft, large as is the R-100 already, and unwieldy and dangerous as such giants are to handle at mooring masts, in hangars or on the ground. What really is meant, however, may be more closely defined. It is a large ratio of structural strength to size. This can be attained, it is true, by increased size, since the greater lift thus provided would permit more weight devoted to the metal of the ship, as well as more available for paying load.

There is another way, however, in which greater strength could be provided, even with ships of the present size. Were it possible to combine this greater strength with lessened weight of the metal structure itself instead of increased weight, this would provide the desideratum agreed upon as necessary; that is, a greater available lift both for load and for maneuvering. Nor are greater strength and greater lightness necessarily incompatible. What is needed are new metals, just as the development of the strong aluminum alloys similar to the original duralumin has made the present ships a reality, whereas with earlier metals they would have remained a dream.

In pure theory, there probably is no metal now available which develops more than a fourth or a fifth of the strength of which it should be capable. The reason is that metals consist of tiny, microscopic crystals piled together inside the metal mass like the grains in a rope of sand. That article is notoriously weak, and it is instructive to remember why. It is because the grains pull easily apart; slip easily over and past one another. Precisely the same thing is true of a duralumin girder or a steel wire. The full strength of the metal atoms never is utilized because the metal crystals pull apart too easily. Virtually all of modern metallurgy has been devoted to devising ways and means of fastening the tiny unit crystals of the metal more firmly to one another, so that as large a fraction as possible of the real strength of the metal may be displayed.

There is no reason to imagine that progress in this direction has reached its limit. Three very light metals are available in laboratories in addition to the present aluminum: beryllium, magnesium and lithium. All three, it is true, present disadvantages. Beryllium is expensive and difficult to purify. Lithium and magnesium yield too easily to corrosion. Yet the experts have good hope of protecting, strengthening and cheapening these metals, just as aluminum, also once a chemical curiosity, has been protected, strengthened and cheapened by the metallurgist's skill.



The kitchen aid, parts (including the motor housing and end pieces) are die cast from an alloy of Horse Head Zinc

"COME OUT OF THE KITCHEN" sings this die cast labor saver to the housewife . . . . ¶ Die castings are also industrial labor savers. Cast to close tolerances, they eliminate much machining. Flexible in design, they eliminate excess parts. . . . ¶ And made from alloys of Horse Head *uniform quality* Zinc (as a majority of them are) they give the rugged, long-life service so necessary when labor saved is to become profit gained.

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Editorial Comment

In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.—H. W. GILLETT, *Editorial Director*

"Rare" Metals

We like to glance over the advertising pages of foreign metallurgical publications, to see what foreign metallurgists consider worth bringing to public attention in that way. In a recent issue of Metallwirtschaft, we noted a Siemens and Halske advertisement stating that an endurance test of a copper-beryllium alloy of 2.5% Be, after a definite heat-treatment, which was described, had been run 16 million cycles in an endurance test at 70 kg./mm.^{2} (100,000 lbs./in.^{2}), and was still unbroken, while phosphor bronze, presumably hard-drawn, at 40 kg./mm.^{2} (57,000 lbs./in.^{2}) was broken at less than half a million cycles.

In the same issue, was an advertisement asking for proffers of metallic indium in "thousands of ounces," or of indium-bearing materials.

In a recent issue of another German periodical, there was mentioned a German patent dealing with aluminum-gallium alloys. Of course a patent doesn't mean anything as to possible commercial use, but mention of gallium alloys in any sort of literature is rare.

There seems to be much increased interest in lithium and claims, that appear extravagant, are made for it as an alloying element in lead-base bearing metals, and in complex aluminum alloys.

Our own advertising pages have been carrying references to the commercial uses for tantalum and zirconium.

It was not so long ago, before the war, that molybdenum was as "rare' a metal as beryllium is now, and far more so than tantalum is to-day. Few of the metals now classed as "rare" can be expected to be found in such abundance, or to be so indispensable for applications that lead to tonnage uses, as was the case with molybdenum, but it is obvious that the metallurgists and chemists of the future, and not too remote a future at that, must be acquainted with the properties and idiosyncrasies of several metals that they now only know by name.

Bowls and Frying Pans

Some research problems have a handle to be grasped, like a frying pan. One can get hold of it at the start, the problem is perfectly definite and the question is not what to do but how to do it. If fairly standard methods of attack will obviously apply, all that is required is to get busy.

But many other problems are like a bowl, there is no place at which to start. Fitting a handle to it so it can be manipulated like a frying pan is a necessary preliminary. The chemist's casserole is far more readily used than the porcelain dish, and while we may mix our batter in a bowl, we bake the pancakes on a griddle, or in a frying pan, in something with a handle to it. The utensil with the handle is closer to the ultimate consumer of the pancake.

Typical bowl problems are those that confront an industry as a whole, or a trade association, when it seeks to expand the uses of, and markets for, its product. Silver producers, for example, are desirous of extending the commercial uses for silver in the hope that demand may be stimulated sufficiently so the price may rise to a point where the mines, that have been shut down on account of the drop in price, may re-open. What alloys should the silver people study? Should they search again for a "non-tarnishing" sterling silver for household use, handicapped by the legal requirements as to silver content of sterling, and hampered by the fads and foibles of those who set the "styles" in silver-ware for wedding presents? Should they explore the possibilities in new alloys that might be as fitted for kettles and piping for some chemical work as is pure silver, but contain enough less silver to make them cheaper? Or should they look for some benefit to be derived from the addition of a very little silver to some alloy, say steel, that has tonnage uses?

Probably few of them will do anything at all in the line of constructive research, but will rather agitate for legislation to interpose some artificial barrier to the law of demand and supply instead of trying to increase the demand, but if they should tackle the job, they certainly have a bowl to deal with, and not a frying pan.

When a firm first decides to go into research, as differentiated from plant control and trouble shooting, and establishes a research laboratory, the weightiest task of the research men is to decide what lines of investigation to take up. Economics are more important than metallurgy in such decisions for, if the metallurgy is good, and the economics faulty, the research work may result in a nice paper in some journal, but no dividends to the stockholders. If one has such large funds at his disposal that all reasonable avenues for research can be followed out, a few successes will be sure to repay the expenditure on both the productive and the unproductive lines of investigation. But the research laboratory is seldom so liberally backed, and hence it must choose among a few lines of attack. Chance plays quite a part in the success of the average research laboratory, not so much in the prosecution of the work itself, as in the selection of the problems.

There are few college courses in fitting handles to bowls, though there are professors who manage to impart some facility along this line to their students, but when the professor does so, he probably does not know he is doing it. It is worth while for every research man to re-read, once a year, Dr. Becket's presidential address,[1] "An Opportunity for Conservation," which points out the necessity for consideration of the economic applicability of the results of research before starting the work.

[1] *Transactions American Electrochemical Society*, Vol. 49, 1926, pages 17–27.

Coöperation

It is beyond the capabilities of any one individual to watch all the interesting metallurgical information even in publications confined wholly to metallurgy, assuming that he has the ability to read the languages of these periodicals.

Through the *coöperation* of a group of metallurgists familiar with the language of the original and qualified to pick out the important information, it is possible to obtain the information by devoting *two hours* monthly to reading the Current Metallurgical Literature Review.

The value of this literature review increases with age as it opens up to the user of METALS & ALLOYS the wealth of data in related but separate branches of technology which does not appear in text or hand books.

Readers' Views and Comments

To the EDITOR of METALS & ALLOYS:

Dear Sir: On page 431 of the April issue of METALS & ALLOYS is a statement that the modulus of elasticity of cold drawn steel tubing may be as low as 20,000,000 instead of 28,000,000 which is usually used in design.

As far as I know, the modulus of elasticity is not appreciably affected by mechanical or thermal treatments.

Jeffries and Archer, in their book "The Science of Metals," state that—"Beilby tested the elasticity of metals by making reed vibrators of them and observing the pitch and intensity of the notes produced." The results obtained indicated that cold-worked metals have a slightly lower modulus of elasticity than do annealed metals.

Further on they state:

> "Figures are often given, particularly in handbooks, indicating that the elastic modulus is greater in the cold-worked than in the annealed condition. Such results are reported especially for the softer metals and alloys like copper and brass, whose true elastic limits are quite low when in the annealed condition. The lower moduli reported for the annealed metals were probably calculated from stresses which exceeded the true elastic limit. If there is any real difference in modulus, that of the annealed metal is probably the greater."

The above quotations indicate that the value of 20,000,000 given in METALS & ALLOYS is unquestionably too low and the value of 28,000,000 as usually used in design is more nearly correct.

J. B. ROMER, Chemist

The Babcock & Wilcox Company

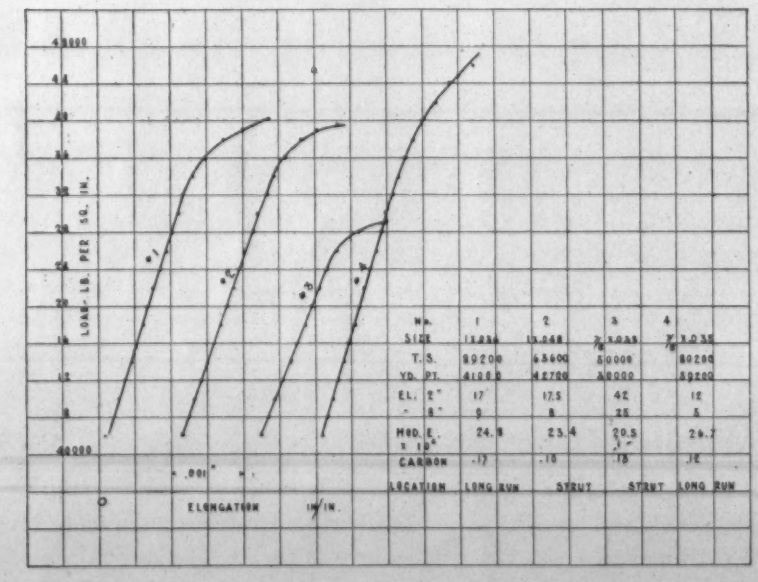
To the EDITOR of METALS & ALLOYS:

Dear Sir: I have the following comments to make on Mr. Romer's letter.

The modulus of elasticity for cold drawn tubing is quite variable, especially in that grade known as mechanical tubing of a carbon content less than 0.20 per cent. I regret that I was not a little clearer in my article in stating that this was the modulus of the tube and not necessarily the material, although as far as its application in the standard formula is concerned, the former is the physical characteristic in which the designer is interested.

Mr. Romer has quoted authorities who were working with standard test pieces and yet you will note that Beilby's tests indicate that cold-worked materials may have a modulus differing from annealed material and the same admission is made in the chapter quoted from Jefferies and Archer.

The results which I quoted were obtained at Wright Field and represent the results of a number of tests on individual tubes.



The curve herewith will indicate the type of stress-strain curves which we have obtained from data on tubing cut from airplane structures. Each one of these curves was taken from a sample cut from a strut removed from an airplane which had failed in service; that is, the strut had bent. The specimen was taken from the unbent portion and should not have been affected in any way by the original failure as all the columns were in the Euler range, that is, the ratio of length to radius of gyration exceeded 120. These tests were made on full-size test specimens approximately 16 inches long with an 8-inch gage length using a Ewing extensometer which reads direct to 0.0002 inch. The load was applied in either an Olsen testing machine or an Amsler testing machine of a maximum capacity of 20,000 pounds. The load was applied manually in the case of the Olsen machine. The rate of application is on the order of 0.05 inch per minute. This, of course, will vary somewhat, especially with the manual operation. An initial load of approximately 5000 pounds per square inch was applied to the tube before the readings on the extensometer were recorded. The results of the modulus were taken from curves plotted on large cross-section paper using a scale of 4" = 0.001 for the stress readings. The curves have been replotted from the data and the modulus may not agree with that taken from larger plotting.

We have never included a modulus of elasticity determination in our specification for tubing, but have frequently run across tubes which on the bending machine gave a large deflection and which later tests indicated a low modulus. These tubes, of course, have never been in service. In fact, the situation was so bad that we sent our Inspector with a bending machine to all our Repair Depots and sorted out all the tubing with a low modulus.

Chrome-molybdenum tubing and tubing with a carbon content above 0.20 is much more uniform in this respect and we have never experienced any difficulty, although occasionally a piece of chrome-molybdenum tubing will show a modulus as low as 26,000,000.

J. B. JOHNSON,
Chief, Material Branch

Material Division Air Corps,
War Dept., Wright Field, Dayton, Ohio

Pouring Aluminum at Night

To the EDITOR of METALS & ALLOYS:

Dear Sir:

"The most experienced furnace hand will make mistakes on the first sunny day after a dull spell." The above appears in "Aluminium Foundrywork," a book distributed by the British Aluminium Co. The paragraph it was taken from called attention to the fact that success in aluminum foundry work depended on a closer control of temperature than is necessary with brass.

Reading it recalled an experience the writer had some years ago, when operating a very small brass foundry with a fellow-molder as a partner. We received a rather large order for aluminum pulleys. It was a rush order and we were told that unless delivery could be made on a certain date, not to accept it. We saw no reason why we could not get them out on time, and started to make them. Unfortunately my partner was taken sick that night and it was up to me to get the order out, which made it necessary to work nights. Realizing that molten aluminum would look brighter at night, than it would in the day time at the same temperature, the question was, what could be used that would enable me to tell the proper pouring temperature. I do not know, how rosin came to my mind, but that did the trick.

I found that if a piece of rosin, the size of a small pea, was thrown on molten aluminum that was dark cherry-red, it would not flare up or burn for several seconds. While if it was hotter, it would flare up immediately—so rosin was our pyrometer at night pouring.

With the lady that had charge of the commissary department at home to do the skimming, we got the order out on time. I remember it was 11:30 Thursday night when we called it a day; 10:30 Friday and about the same time Saturday night when the last one was poured.

JOSEPH P. MCGINNIS

Syracuse, N. Y.

Editor's Note: This is analogous to the use of a pine stick as a make-shift "pyrometer" in the rolling of aluminum, and like that will serve as a rough guide. But this only tells whether the temperature is or is not above a given point. Each casting has its own proper pouring temperature, depending on such factors as wall thickness of the casting, gating, etc. To determine this within the proper limits all progressive foundries which make aluminum castings regularly use regular pyrometers. The editor well remembers his own experience 20 years ago in introducing pyrometers in an aluminum foundry. The foremen had them available, to use or not, as they wished. Some used them and some dropped them "accidentally." But the reports on defective castings soon showed the advantages of using them, and before long those who had intentionally damaged the instruments howled the loudest for a replacement when a real accident did occur.

The Selection of Tin for Fabrication

By C. L. Mantell*

In this paper an attempt has been made to discuss some of the effects of impurities in commercial forms of tin metal. Emphasis is placed upon the fact that all tins are not suitable for specific purposes and that due care and consideration should be given in the selection of the ingot tin for any manufacturing use. In general, far less is known of the effects of working and fabricating of the metal than would be expected because of the relative ease and ordinary lack of difficulties encountered when applying these processes to tin. In some commercial plants losses by drossing are of considerable importance. The relation between impurities in the tin and drossing has been pointed out. It is to be hoped that manufacturers who are remelting the material in the course of its plant use will come to a greater realization of the importance of doing this remelting under controlled conditions, with perhaps some consideration of methods of thermal refining of the metal. In addition, some of the physical properties of tin of importance in rolling, drawing and other fabrication processes have been discussed, with some minor mention of the place these properties fill in connection with design of machines.

The widespread and varied industrial use of tin metal would be expected to carry along in its train a considerable number of investigations of its properties, both of a chemical and physical nature as well as structural changes produced in working. However the ease of fabrication of the metal by rolling, drawing and casting has prevented attention being given to the studies of its properties. Carefully controlled plant practice, as in the case of other metals, has ordinarily not been necessary in the case of tin. As a result, tin metal was just "tin" which seemingly could be abused in many ways, with little thought necessarily given to its origin, history or composition and ordinarily without serious detriment to the final product resulting from such a viewpoint. Desire for increased industrial efficiency as well as the economic intercompetition of metals has in recent years somewhat changed this attitude. In this paper an attempt will be made to discuss the effect of some impurities on the characteristics of tin and its working, as well as the importance of some of the physical properties of the metal as they affect rolling.

In general, tin is valuable for its high malleability, ductility, corrosion resistance to atmospheric oxidation and mild corroding agents, its low melting point, and its white color and luster. The mechanical strength of tin is low but ordinarily is of little direct value. It may even be a disadvantage if it be obtained at the sacrifice of other valuable characteristics. The mechanical properties have, however, long been used as tests of quality. For example, the test applied on the London Metal Exchange consists of taking a wedge-shaped piece of tin ingot which is nicked, then bent. The bend must be smooth and free from tears in order that the tin be judged to be "of good merchantable quality." In addition, the metal must assay not less than 99.75% tin.

The common impurities in commercial ingot tin are antimony, arsenic, lead, bismuth, copper and iron. Their effect is to render it harder and grayer. The chief desire of the user of tin is to obtain uniformity of working properties. Such uniformity can only be obtained with uniformity of metal. Commercially tin is dealt in by brands which are divided into classes known as Standard, assaying 99.75% tin, and 99% tin, assaying not less than that percentage of the metal. Twenty-four brands of tin are traded on the New York Metal

* Consulting Engineer, New York.

Table I—Typical Tin Analysis
(Mantell)

	Tin	Antimony	Arsenic	Lead	Bismuth	Copper	Iron	Silver	Sulphur	Cobalt
American Electrolytic tin	99.928	0.002	0.002	nil	0.042	0.026	trace	...	...	...
Banka	99.950	0.007	nil	trace	nil	0.018	0.045	nil	trace	...
Billiton	99.960	0.006	nil	nil	nil	0.023	nil	nil	nil	...
Penang	99.939	trace	0.013	trace	nil	0.016	0.028	nil	0.004	...
Singapore	99.870	0.008	0.045	0.034	0.003	0.052	0.003	0.006	0.005	...
Mt. Bischoff	99.847	0.015	0.015	0.042	0.001	0.017	0.063	...	...	...
	99.795	0.015	0.063	0.037	0.005	0.035	0.042	trace	0.008	...
Pyrmont	99.938	0.017	0.019	trace	nil	0.022	trace	nil	0.004	...
Irvine Bank	99.580	0.062	0.034	0.221	0.025	0.126	0.002	0.018	0.004	...
Mellanear, Lamb & Flag	99.190	0.160	0.060	0.160	0.350	0.060	0.020	...	...	...
Williams, Harvey & Co:										
No. 1	99.860	0.015	0.040	0.004	0.005	0.047	0.003	nil	0.006	...
No. 2	99.560	0.166	0.037	0.162	0.007	0.050	0.005	trace	0.013	...
No. 2-a	99.350	0.245	0.065	0.223	0.015	0.042	0.016	trace	0.013	...
No. 3	99.200	0.300	0.037	0.396	0.007	0.100	0.013	0.014	0.006	...
No. 4	99.941	0.011	0.022	trace	0.001	0.020	trace	trace	0.005	...
Redruth	99.160	0.176	0.053	0.177	0.017	0.445	0.041	0.006	0.008	0.012
O. T. Lempriere & Co	99.880	0.011	0.016	0.019	0.012	0.026	0.020	nil	trace	0.008
Cornish Refined	99.880	0.012	0.006	0.014	trace	0.046	0.003	...	0.017	...
Cornish Lamb & Flag	99.321	0.174	0.034	0.068	trace	0.205	0.040	...	0.044	...
German Lamb & Flag	99.080	0.150	0.080	0.500	0.060	0.080	0.050	...	...	...
Th. Goldschmidt:										
No. 1	99.860	0.004	nil	0.102	nil	0.043	trace	nil	trace	...
No. 2	99.460	0.015	nil	0.425	nil	0.069	trace	nil	trace	...
No. 3	99.150	0.122	0.046	0.143	0.112	0.352	0.007	0.006	trace	...
Sutton, T., & Sons	99.550	trace	0.022	0.342	0.015	0.045	0.010	trace	nil	trace
Chinese No. 1	99.343	0.031	0.040	0.434	0.007	0.052	0.010	trace	0.011	0.072
Wing, Hong & Co.:										
No. 2	98.662	0.039	0.035	1.035	0.012	0.134	0.014	trace	0.011	0.058
No. 3	95.280	0.381	0.050	3.995	0.020	0.106	0.026	0.018	0.008	0.116
Penpoll:										
No. 1	99.720	0.118	0.054	0.041	0.007	0.052	0.004	0.009	0.007	...
No. 2	98.710	0.569	0.042	0.546	0.055	0.103	0.007	0.015	0.004	...
No. 3	99.300	0.325	0.056	0.212	0.050	0.088	0.002	0.021	0.009	...
Special Refined	99.9309	0.019	trace	0.0256	0.0015	0.0102	0.0087	trace	...	0.0041
Refined	99.800	0.118	0.054	0.041	0.007	0.052	0.004	0.009	0.007	...
Capper Pass Chempur	99.9946	trace	trace	trace	trace	0.0038	0.0016	...	...	Zn trace

Exchange against its contracts. A table of typical analyses of these tins is given below. The class A or Standard tins, deliverable at contract price, includes Banks, Straits (Straits Trading Co., Eastern Smelting Co., Po Hin, Ban Hok Hin); English Refined (Williams Harvey Mellanear refined, Penpoll Special refined, Cornish refined, Capper Pass & Son); German Refined (Th. Goldschmidt "Baum," Berzelius " Rose Brand," Zinnwerke Wilhelmsburg refined); Belgian Refined (Union Miniere du Haut Katanga); Australian Refined (O. T. Lempriere & Co., Mt. Bischoff, Pyrmont). The class B or 99% tins, delivered at $1^1/_8$ cents per pound under contract, consists of English Common (Williams Harvey Mellanear common, Penpoll common, Cornish common, Thames Metal Co.); German Common (Th. Goldschmidt "Volta," Th. Goldschmidt "Tego," Zinnwerke Wilhelmsburg common); and Chinese Tin No. 1. The brands are either indicative of the origin of the ore from which the tin was smelted, or else identify the smelter as they carry his name or trade-mark. Purchase of tin by analysis with disregard of brand appears to be decidedly the unusual rather than the usual method, inasmuch as the brands are indications of quality.

Gueterbock and Nicklin[1] studied the effect of the addition of impurities commonly found in commercial tins on the properties of very pure metal containing total impurities of 0.0082% distributed as follows:

Lead	0.0025%
Antimony	0.0031%
Copper	0.0004%
Bismuth	0.0004%
Sulphur	0.0002%
Iron	0.0016%
Arsenic, zinc, tungsten, nickel, cobalt, silver and gold	nil

The properties studied were freezing point, hardness, compression tests, tensile tests, electrical conductivity, density, and drossing. Small additions of lead, copper, arsenic, iron and zinc, the additions being of the order of impurities found in commercial tins, lowered the freezing point of the metal, while antimony and sulphur increased it. In a mechanical test, very small quantities of copper and lead were found to soften the metal but the hardness increased when slightly greater quantities of these were added. For example, the pure tin under test showed a hardness of 5.4 on the Brinell scale. The addition of 0.048% lead decreased the hardness to 4.5, but the addition of 0.253% lead increased it to 6.7. The addition of 0.012% copper dropped the hardness figure to 4.4, but tin containing 0.050% copper showed a hardness of 5.3. The addition of 0.012% bismuth increased the hardness to 5.9, while greater quantities such as 0.056% decreased the hardness to 4.6. The effect of other additions such as antimony, arsenic, sulphur, iron, and zinc was to increase the hardness, the addition of 0.24% zinc showing a hardness figure of 11.8. The effect of increase in the impurities in tin on values obtained in compression tests was all in the same direction for the different materials added, in that the compression yield points were increased. Similar results were obtained for breaking loads in tensile tests with the exception of bismuth, the value of which decreased, and sulphur, which had little effect on the tensile strength. The tabulated results are given in Table II.

In the test for specific electrical conductivity, copper being taken as the standard 100, the purest tin had the highest conductivity. The effect of different impurities or combinations thereof was very erratic. It is doubtful whether this property could be made to be a useful guide as to the quality of tin.

An approximate guide to the quality of tin is given by the bending test mentioned previously. The effect of impurities on the appearances of bends is tabulated in Table III. Copper and iron appear to have little effect on the structure exhibited at the broken surface. Lead, antimony, bismuth and arsenic, as well as sulphur, affect the bend appreciably while unusually high zinc contents of the metal markedly change the appearance at the broken surface.

[1] *Journal Society Chemical Industry*, Vol. 44, 1925, pages 370T–374T.

Table II—Mechanical Tests
(Gueterbock and Nicklin)

Description of Specimen	Hardness Number	Compression Yield Point	Yield Point	Tensile Tests Breaking Load	Red. of Area %
Standard tin	5.4	0.66	0.76	1.20	100
Tin containing:					
0.048% Pb	4.5	1.10	0.92	1.30	100
0.253% Pb	6.7	1.45	1.08	1.74	95
0.048% Sb	5.3	0.91	0.94	1.34	100
0.243% Sb	5.8	0.99	0.90	1.40	100
0.012% Cu	4.4	1.04	0.93	1.36	100
0.050% Cu	5.3	1.10	1.14	1.58	98
0.012% Bi	5.9	0.85	0.76	1.11	100
0.056% Bi	4.6	0.96	0.68	1.05	100
0.008% As	7.8	1.13	1.10	1.50	100
0.055% As	8.7	1.40	1.17	1.51	96
0.005% S	5.4	0.82	0.79	1.22	100
0.036% S	6.0	0.77	0.69	1.21	100
0.011% Fe	5.4	0.78	0.80	1.42	100
0.058% Fe	5.7	0.98	0.83	1.30	100
0.040% Zn	5.8	1.15	0.99	1.60	100
0.240% Zn	11.8	2.45	1.92	2.68	74

All loads expressed as tons/in.^{2}

Table III—Bends and Appearance
(Gueterbock and Nicklin)

Description of Specimen	Class of Bend	Description of Specimen	Class of Bend
Standard tin	I	Tin containing:	
Tin containing:		0.008% As	II
0.048% Pb	II	0.055% As	II
0.253% Pb	II	0.005% S	II
0.048% Sb	I	0.036% S	II
0.243% Sb	II	0.011% Fe	I
0.012% Cu	I	0.058% Fe	I
0.050% Cu	I	0.040% Zn	I
0.012% Bi	I	0.240% Zn	III
0.056% Bi	II		

I. No cracking, fine granular surface. II. No cracking, lumpy. III. Slight signs of cracking.

In many cases tin metal employed for various uses has to be periodically remelted; in some others, baths of tin are kept molten for long periods. In both cases losses by drossing are an appreciable source of waste. Many of the impurities commonly found in commercial tins oxidize more readily than does the tin. The drosses will, therefore, contain a relatively higher proportion of impurities than the original metal, with resultant decrease in value when they are offered for sale to secondary metal organizations. Crucible drossing tests gave the results indicated in Table IV below.

Table IV—Drossing
(Gueterbock and Nicklin)

Description of Specimen	Dross % (Wt.)	Description of Specimen	Dross % (Wt.)
Standard tin	1.7	Tin containing:	
Tin containing:		0.008% As	2.0
0.048% Pb	1.8	0.055% As	1.9
0.0253% Pb	1.8	0.05% S	1.5
0.048% Sb	1.6	0.036% S	2.3
0.243% Sb	2.3	0.011% Fe	1.5
0.012% Cu	1.7	0.058% Fe	2.6
0.050% Cu	2.2	0.040% Zn	2.0
0.012% Bi	1.5	0.240% Zn	3.6
0.056% Bi	2.2		

Lead in small amounts in commercial tins softens the metal, but additions of the order of $^1/_4$% cause distinct hardening. The same amount of lead does not increase the amount of dross. Antimony impurities affect the hardness of tin very little but markedly increase losses due to dross. Copper in very small amounts, say of the order of 0.01%, softens tin. Additions of 0.05% show practically the same hardness as pure tin. The presence of copper is shown by the marked influence on the surface of cast strips or bars, and with tins containing as much as 0.05% copper, losses due to drossing are increased. Bismuth and arsenic increase the amount of dross produced when tin metal is melted, and arsenic hardens the tin.

Sulphur encountered as an impurity, particularly in rubber plants where tin sheet is used as a gasket in vulcanizers, in small percentages has very little effect on the properties of tin, but when the metal is remelted it causes higher losses due to drossing than are encountered in the original pure tin metal. An alloy of tin containing 0.7% sulphur is distinctly brittle. Iron, due to the formation of iron-tin alloys such as hardhead, would be expected to harden the tin but in the case of the

very small quantities present as impurities in commercial tins, does not have the effect expected. High-iron tins show greater losses in dross on remelting than do those with very small quantities of this impurity. In the case of zinc with which tin may become contaminated in processes involving the remelting of scrap metal, as little as 1/4% will produce a great change in the properties of the original tin. The hardness is increased very markedly and oxidation losses on remelting are almost twice as great as are obtained with zinc-free tins. It is very difficult when a zinc-containing tin is remelted to skim the surface of the molten metal clean, in that a white film remains after skimming.

The foregoing discussion as to the action of impurities emphasizes the importance of the quality of tin obtained for or consumed in any manufacturing process, and proves that different results will necessarily be obtained with different tins from different sources having different origins and histories. The effect of impurities discussed will naturally be cumulative and additive in the case of secondary tins or remelted products which are not made to undergo some sort of purification or refining process. Emphasis should be laid on the fact that tin as commercially obtained, as far as specific uses are concerned, exists in many different varieties but must be chosen with due regard to impurities; but for general application it can be chosen, roughly, from the three general classes mentioned—that is, Standard tin, 99% or common tin, and a third class consisting of tins running lower than 99%. For example, the manufacturer of collapsible tubes or tin foil must be quite particular about the quality of his tin, the kind and amount of impurity, as well as carefully regulate and control remelting of scrap and waste resulting from manufacturing processes. The producer of tin coated copper wire ordinarily need not be concerned with the amount of copper usually found in commercial tin; and the manufacturer of solder and tin alloys in general can use the more impure forms of the metal. Particularly is he not bothered with worries about the employment of high-lead tins.

Operations involving rolling, drawing, or extruding of tin metal are in wide use in industry. It is a matter of considerable surprise to find that there are comparatively few published records of observations of the strains produced by compressive stresses involved in the working of metals in general. A discussion of some of the work done in this field may be of interest.

Metals under stress show two distinct periods during the application of forces, the first the period of perfect elasticity which corresponds to variations of dimensions proportional to the forces applied; the second the period of imperfect elasticity during which the changes of dimensions increase more rapidly than do the forces. In the second phase of deformation an ultimate condition results in which a given force, sufficiently great, continues to produce deformation without limit. This condition corresponds to the geometrical definition of a third period, that of fluidity. Coe[2] observed, during the course of some experiments on cylinders of tin, lead and their alloys, that, when tested in compression under regularly increasing loads, the changes in height and diameter, when plotted in the form of load strain diagrams, did not yield smooth curves during the semi-plastic and plastic ranges but that there was a discontinuity in the curves. The break was not readily observed when the ordinary method of graphical representation was adopted; but it was shown very clearly when the difference in the dimensions of the cylinder for unit increase of load was plotted against the load of the specimen. These observations led to the carrying out of compression tests on other metals. The same phenomenon was observed in nearly all cases. It was more marked in some metals than in others and in the case of a particular metal more clearly defined when the sample tested was initially in a state of stress, such as that produced by rolling or drawing.

[2] "Behavior of Metals under Compressive Stress," *Journal Institute of Metals*, Vol. 30, 1923, page 314.

Under the conditions of his experiments and within the limits of his apparatus, Coe found that rate of flow as measured by the change in length of the test specimens increased with increase of load, after the elastic limits and yield points of the metal had been exceeded, up to the maximum which was represented either by a peak or by an inflection in the curves. Subsequently the rate of flow tended to diminish.

The term "critical plasticity" was used to describe abnormal change in the degree of plasticity which metals exhibit at particular loads. When the behaviors of tin under compressive stresses are plotted, the curves all show deflections at approximately the same load, whether it be applied in increments of 0.1 ton or of 0.5 ton.

Some of the results of tests of tin in compression are tabulated, as well as some obtained in tension. In Table V values are given for the stresses resulting with increased load when the stresses are calculated on the enlarged section produced by the compressive forces. It will be noticed that after certain pressures are reached the net resulting pressure produced on the enlarged section in terms of unit of area becomes constant, indicating an approach to the condition of fluidity. In other words, at these pressures deformation proceeds entirely out of proportion to applied pressures. The tests were conducted on electrolytic tin analyzing 99.99% tin.

Table V—Tests in Compression

(Coe)

	Chill Cast	Pressed and Annealed at 100° C.		
	1	2	3	4
Elastic limit, tons/in.²			0.05	
Stress giving critical plasticity, tons/in.² on initial section	1.8	2.1	2.3	1.9
Stress giving critical plasticity tons/in.² on enlarged section	1.08	1.29	1.34	1.24
Reduction in length at load giving critical plasticity, %	32.2	31.4	37.2	
Tests in Tension				
Elastic limit, tons/in.²			0.1	
Maximum load, tons/in.²			1.31	
Elongation on length $= 4\sqrt{A}$ %			86	
Brinell hardness	5.2		5.0	
Density, H_2O 4° C.	7.298	7.305		

Table VI—Tin-Pressed and Annealed at 100° C.

(Coe)

Load, Tons	Length, Inches	Diameter	Stress on Enlarged Section, Tons/in.²
0.70	0.8030	0.8596	...
0.75	0.7768	0.8766	1.263
0.80	0.7498	0.8948	1.294
0.85	0.7207	0.9148	1.322
0.90	0.6914	0.9353	1.341
0.95	0.6598	0.9606	1.347
1.00	0.6281	0.9860	1.343
1.05	0.5990	1.0125	1.338
1.10	0.5725	1.0360	1.337
1.15	0.5450	1.0700	1.310
1.20	0.5210	1.0910	1.311
1.25	0.4980	1.1150	1.310
1.30	0.4780	1.1350	1.310

In general, plastic deformation in the case of tin metal proceeds at loads of a ton or a little more per square inch. Machines for the fabrication of tin metal need be designed, therefore, only to apply pressures of this magnitude in order that satisfactory deformations be produced. If machines be designed to exert larger pressures than this, the expected pressures will not be reached but the object (bar, slab, or billet) will perhaps be deformed at an increasing rate but not at the pressure for which the machine was designed.

The color of tin is white with a slightly bluish tinge. Nickel, in comparison with tin, is brown and chromium definitely blue. Tin is whiter than silver or zinc. When light passes through exceedingly thin films of tin, the metal transmits various shades of brown. When highly polished tin has high light reflectivity, it also possesses a brilliant luster which depends to a large extent upon the temperature at which the metal is poured when cast. If the temperature be too high, iridescent colors may show on the surface as the result of oxide films; if the pouring temperature be too low, the surface is dull. Small amounts of foreign metals, such as lead, arsenic, antimony and iron, decrease the luster of tin and impart a yellowish tinge.

The structure of tin is decidedly crystalline. When a bar of tin is bent it emits a characteristic creaking sound called the "cry" of tin, resulting from the grinding of the crystals against each other during the bending of the metal. Tin metal has its crystals broken up by cold working, but grain growth occurs rapidly under the influence of heat. Metal which has been cast at a low temperature may become fine-grained as the result of mechanical work, but if the material be heated, say at 110° for a half hour or for a few minutes at 150°, recrystallization occurs. The fine grain structure obtained by quenching molten tin in water is unaffected by annealings over long periods at temperatures below the melting point. If so-called "block tin," however, has its crystalline structure extremely subdivided by severe compression or working, it can be caused to recrystallize at 150°. Tin crystals sometimes show lines which are due to stresses set up during rapid growth.

Cold rolled tin shows a tendency to recrystallize at ordinary temperatures immediately after rolling. If annealing be carried out at 170–180°, secondary recrystallization occurs, the smaller crystals growing at the expense of their neighbors. The resultant metal has a very coarse crystalline structure. If rolled once more and allowed to stand, the primary crystals which form are larger than before, but about the same size as those produced by annealing at temperatures up to 150°. It is well known that tin foil cannot be readily produced in different hardnesses as the metal does not work harden.

An X-Ray Study of the A_3 Point of Iron and Some Iron-Nickel Alloys*

By Oscar L. Roberts† and Wheeler P. Davey‡

Besides the direct information on the iron–nickel system contained in this paper, it is of interest in other ways. Technique for the X-ray spectrographic examination of alloys at temperatures up to 950° C. is described. Experimenters in this field will find that portion of especial value.

The alpha-gamma inversion in pure iron, reduced from the oxide by hydrogen, is (within the 3° C. limit within which the temperature figures are considered reliable) the same on heating and cooling, contrary to previous investigators. Moreover, the existence of this inversion in pure iron is in opposition to the theory of Yensen (see Fig. 2, page 576, May 1930 issue of Metals & Alloys) that pure iron is free from allotropic transformations.

However, the method of preparation does not insure the absence of oxide and Yensen's theory refers only to oxygen-free iron. We would like to see some of Yensen's iron that has been refined so as to be free from both carbon and oxygen subjected to X-ray spectrographic study at temperatures above A_3.

Introduction

The iron–nickel system has long been a source of interest owing to the fact that alloys of these metals possess a wide range of properties. These large ranges of properties which are, for the most part, due to irreversible conditions indicate that equilibrium of the system is the exception rather than the rule. Investigations of this system have practically always been with iron, nickel and a certain percentage of other constituents. The present investigation deals with very pure iron and iron-nickel alloys. We find by means of X-ray crystal analysis that in pure iron the Ac_3 and the Ar_3 points are the same, but in the Fe-Ni alloys they are not the same. We have determined the A_3 point in pure iron and the Ac_3 point in a series of pure Fe-Ni alloys to within ±3° C.

Survey of Literature

A complete review of all the work reported in the literature on the iron–nickel system will not be presented here. Investigations dealing with iron-nickel alloys which contained appreciable amounts of impurities are discussed or mentioned only in case they have a somewhat direct bearing on the present problem. Furthermore, discussion of alloys which contain larger amounts of nickel than 25% will, in general, be omitted.

The allotropy of iron was first found through studies of the physical properties of iron-carbon alloys. The basic principles underlying the transformations were established by Osmond[1] and by Roberts-Austen.[2] Theoretical explanations of the transitions were offered by LeChatelier.[3] All of the early work on iron alone was carried out on "practically pure" iron but it is very doubtful if the iron was really pure.

The transition point of γ-iron to β-iron as obtained by thermal or electrical measurements on "practically pure" iron is not at the same temperature when the metal is heated from below 900° as when it is cooled from above 900°. The difference in these temperatures varies with the purity of the iron, the rate of heating or cooling and the duration that the iron is held at high temperature. As an example, Burgess and Crowe[4] used the purest iron they could obtain and found the Ar_3 and Ac_3 points to be at 898 and 909° C.

Prior to 1920 the work done on the iron–nickel system consisted chiefly of observations of the magnetic, electrical and thermal properties of the alloys. Osmond's[1] work and the studies of Hanson and Hanson[5] show that thermal arrests correspond very closely to the temperature at which the magnetic and electrical properties show marked changes. The alloys studied by Hanson and Hanson were probably much more free from impurities than alloys used by previous investigators. The alloys were prepared from Armco iron and Mond nickel. The iron contained 0.012% carbon, 0.017% silicon, 0.017% sulphur, 0.014% phosphorus and 0.07% manganese. A complete analysis of the nickel is not given but since an alloy containing 1.09% nickel also contained 0.046% carbon and the iron originally contained only 0.012% carbon, the nickel used must have had carbon present as an impurity. The "pure" iron was found to have a 30° lag between the Ac_3 and Ar_3 points. This lag increased with increasing nickel content. For the iron these points

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† The material here presented was used by the junior author in partial fulfilment of the requirements for the Ph.D. degree at The Pennsylvania State College, June 1930.

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were found to occur at 935 and 905° while for a 20% nickel alloy these two points were found at 625 and 195°. Thus, the effect of nickel was shown to be that of depressing the A_3 point and widening the range between the Ac_3 and Ar_3 points.

Hull[6] in 1917 examined electrolytic iron and iron produced by the reduction of Fe_2O_3, by means of the X-ray diffraction method, and found that at room temperature the structure is body-centered cubic. Attempts were made to secure patterns while the iron was at 700 and at 900° C. but due to fogging of the film these patterns were not obtained. He did obtain a pattern of a silicon steel at 1000° and found the α-structure to exist at this temperature. By the same method of analysis he found[7] nickel to be face-centered cubic. In this same year Andrews,[8] working in Hull's laboratory, reported the results of an X-ray investigation of iron-nickel alloys. The alloys were prepared from Swedish iron and "pure" nickel. All patterns were obtained at room temperature. The results may be summarized by stating that alloys containing 0–22% nickel were body-centered cubic alone, alloys containing 25–27% nickel were body-centered and face centered cubic, and alloys containing 30% or more nickel were face-centered cubic.

Westgren's work[9] in 1921 was the first to show the various structures which exist from room temperature up to 1000° C. He studied iron and nickel steels but the results of the work on the nickel steels will not be discussed because of the very appreciable quantities of impurities present. Although the sample of iron which he used contained 0.15% carbon, the results are so important as to warrant their reproduction here. Patterns were secured while the iron was maintained at 800 and 1000° C. The structures which existed at these temperatures were found to be body-centered and face-centered cubic, respectively. No attempt was made to locate the temperature at which the body-centered lattice changed into face-centered lattice. The temperatures of the specimens, which were in wire form, were measured by means of an optical pyrometer. He states that the readings obtained were found by checking experiments to be not more than 30° too low. It is interesting to know that the modification of iron which is stable at 1000° C. is face-centered, for this arrangement is one of the two possible arrangements for the closest packing of spheres. This supplies a mechanical explanation of why a contraction occurs upon heating iron through the A_3 point. Furthermore, Westgren's study gave conclusive proof that α- and β-iron do not differ structurally. The lattice parameters at 800 and 1000° were given as $2.92 \cdot 10^{-8}$ and $3.60 \cdot 10^{-8}$ cm., respectively. Much importance should not be attached to these values because the difficulty of maintaining the specimens at the center of curvature of the film and the curvature of the diffraction lines makes the measurement of the angle of diffraction difficult and uncertain. In 1922 Westgren and Phragmen[10] repeated this work, using electrolytic iron of 99.98% purity, and confirmed the results obtained previously by Westgren.[9]

McKeehan,[11] in 1923, and Osawa,[12] in 1926, investigated iron-nickel alloys and found that the solid solutions of iron and nickel are formed by a simple substitution of nickel atoms in the iron lattice or vice versa. The heterogeneous range of structure at room temperatures was found to lie between 12 and 36% nickel.

The discovery, by one of the present authors, of a method by which alloys can be produced in an extremely high state of purity made it seem important to investigate the Ac_3 and Ar_3 points of pure iron and iron-nickel alloys made by this method. The phases present were determined by X-ray crystal structure methods.

Preparation of Specimens

Ferric nitrate and nickel nitrate (Baker's Analyzed) were mixed in an aqueous solution, and the hydroxides of these metals were co-precipitated by means of ammonium hydroxide. The precipitation was carried out by squirting a very fine jet of the mixture of iron and nickel nitrates into a solution of ammonium hydroxide. During the addition of the nitrates, the ammonium hydroxide was agitated in a rapidly swirling motion. This method of precipitation brought about an intimate mixture of the hydroxides of these metals. The mixed hydroxides were ignited in an electric furnace and thus converted into the oxides. This ignition was made in an alumina crucible. The mixture of oxides was then pulverized and transferred to another alumina crucible which was enclosed in a small iron container made of iron foil. The container was heated in an electric furnace through which dry purified hydrogen was passed.

The reduction of the oxides by the hydrogen left a mixture of the metals which was as nearly an atomic dispersion of nickel in iron as could be prepared. Following the reduction of the oxides, the central portion of the metals was removed from the crucible and pressed into the form of a rectangular rod by means of a hydraulic press. This rod was heated in an atmosphere of hydrogen to a temperature at which the particles just began to sinter. After the sintering process had continued long enough to produce a coherent mass, the rod was swaged into a cylindrical wire of nearly constant diameter. Some of the rods were rolled, through carefully cleaned rolls, into ribbon or tape form.

The purification of the hydrogen was accomplished by passing electrolytic hydrogen over heated filings of copper, bubbling it through two towers of sulphuric acid, passing it through 20 feet of iron pipe containing metallic sodium and then through $2^1/_2$ feet of glass tubing containing phosphorus pentoxide.

Analyses of the alloys were made spectroscopically to ascertain whether or not any impurities were present. This analysis revealed the presence of a minute trace of silicon. From the method of preparation it is to be assumed that both the iron and the iron-nickel alloys were quite carbon free. The nickel content of the alloys was determined by the dimethylglyoxime method. In general, the ratio of nickel to iron in the alloys was less than that in the original solution, probably because of the solubility of nickel hydroxide in excess ammonium hydroxide.

Although every care was taken to obtain as complete reduction of the oxides with hydrogen as possible, there is still the possibility (not the probability) of oxide inclusions caused by the process of getting the metal into wire. However, the possibility of this influencing our X-ray results is very slight. It is well known that the diffraction effects of metals for long wave-length X-rays, such as Mo Kα which we used, come from very near the surface of the specimen. As will be described in greater detail later in this paper, our specimens were heated repeatedly in an atmosphere of hydrogen during the course of our X-ray tests. It is evident, therefore, that all oxide (down to the mass-action law limit for hydrogen at atmospheric pressure) must have been reduced both at the surface and for a short distance below the surface. If oxide was present in our samples, it must have been in the central portion of the wire where it could not influence our X-ray results. In the opinion of the authors, no oxide was present in the wire in quantities sufficient for even the most refined chemical analysis. Our diffraction patterns made at room temperature show no evidence of crystals of oxide. When our precision measurements of the lattice parameter of our pure iron are compared with similar published measurements on the vacuum fused electrolytic iron of the Bureau of Standards, we can find no evidence of stretching or shrinking of the lattice such as might be expected in the case of solid solution of oxygen.

Apparatus

The experimental work was carried out on two X-ray outfits. The diffraction patterns of the alloys at room temperatures were obtained by means of a General Electric X-ray diffraction apparatus. A Coolidge tube with a molybdenum

target was employed and was operated at 30 kilovolts and 20 milliamperes. The specimens were at the center of a circular arc of 8–inch radius and the photographic film lay on the arc of the circle. The interplanar spacings were derived from the patterns by means of the well-known scale supplied with the General Electric apparatus.

The X-ray apparatus used for the work done at elevated temperatures consisted of a molybdenum target, Coolidge type tube, the necessary transformers, a specimen holder, an optical pyrometer and thermocouple arrangement, a cassette, and equipment for surrounding the specimen with an atmosphere of hydrogen.

The X-ray tube was mounted in a horizontal position in a lead box. Two vertical slits served to define the beam.

In front of the second slit, a flat iron plate was mounted on a stand. This plate supported the oil seal pan, the specimen holder, the cassette and pyrometer. This apparatus is shown in Fig. 1. The oil seal pan, A, was made by placing a

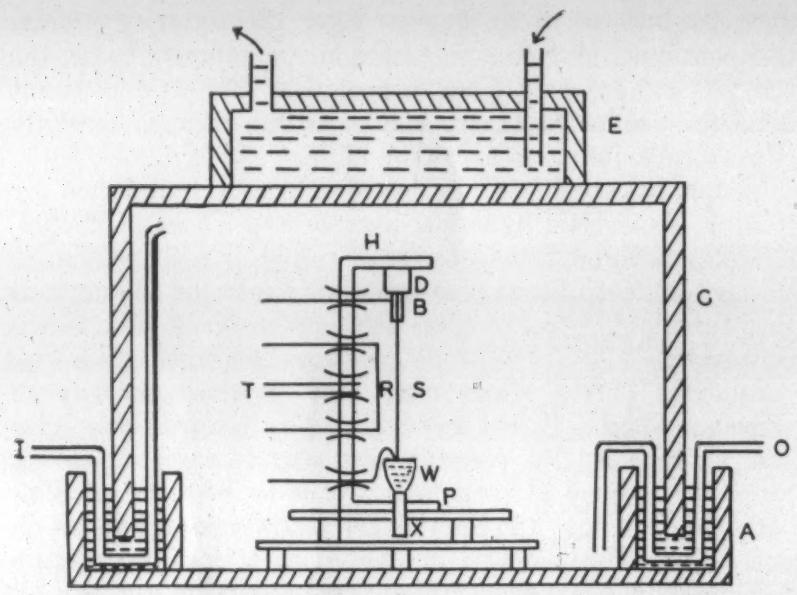

Fig. 1—Diagram of Specimen Holder and Hydrogen Bell

rectangular pan of sheet iron in another somewhat larger pan of similar shape. These pans were soldered together at the contact of their bottoms so as to fix them rigidly in place. This arrangement produced a rectangular channel which when filled with oil served as a seal. The oil used was one of low vapor pressure so as to reduce the tendency to introduce carbon into the specimen. The oil vapor, being more dense than hydrogen, no doubt did not reach the level of the specimen for the hydrogen was continually flowing in at I and out at O and thus was continuously sweeping out the contents of the container, C. The two pans were clamped to the iron plate (not shown in the figure), and a platform, P, of brass was placed inside the smaller pan. Upon this platform the cassette (not shown), pyrometer, R and T, and the specimen holder, H, were fixed in position. The cassette was built so that the film was on an arc of 5–inch radius with the specimen, S, at the center of the arc. A piece of celluloid impregnated with zirconium oxide was used to filter out practically all the radiation except the Kα-doublet. This type of filter shows selective transparency for the Kα-doublet of the molybdenum X-ray spectrum. The specimen holder, H, was a [-shaped piece of brass and was pivoted on the axle, X. This arrangement permitted an oscillation of the specimen to be made during an exposure by means of an attachment not shown in the figure. A screw device, D, permitted the raising or lowering of the specimen. A piece of steatite, B, which acted as an insulator was clamped to the screw device and directly supported the specimen. A small tungsten weight (0.7 gm.) was suspended from the lower end of the specimen and was submerged in a well of mercury, W, which served as an electrical contact. The net downward force on the wire was such that the wire was always kept taut and in the path of the X-rays but yet did not exceed the elastic limit of the specimen at the temperatures used in this investigation.

A piece of metallic ribbon, R, having the same composition as that of the specimen was stretched vertically between insulating lugs attached to the specimen holder so as to be practically parallel to the specimen. The distance between the ribbon and the specimen was about 2 centimeters. The intensities of the heated ribbon and specimen could be visually matched by looking through a glass window in the container, C. A calibrated alumel chromel thermocouple made of very fine wires was spot welded to the ribbon.

The container, C, was a rectangular box of sheet iron which fitted into the oil seal. In each of three of the walls of the container there was a window. Two of these were of glass; one in the right side at C enabled a visual match of the intensities of the ribbon and the specimen to be made and one in the back (above the plane of the figure) permitted an inspection to be made while the box was being oriented to permit the X-ray beam to enter the container. The third window was of very thin mica and admitted the X-ray beam. This window was in the front wall (below the plane of the figure). The inlet and outlet tubes, I and O, for the hydrogen and the wires leading into the container were laid in the oil and passed under the edge of the container. A small tank, E, through which cold water was circulated, was soldered on the top of the container. This cooling device was necessary to prevent the heat from the specimen and ribbon from fogging the photographic film.

The current which heated the specimen was furnished from the d. c. side of a motor-generator set whose nominal rating was very high in comparison to the load drawn from it. In the specimen circuit, two lead storage batteries were floated across the line, and two slide wire resistances and an ammeter were inserted. This arrangement enabled a very steady current to be passed through the specimen. The ribbon was heated by an alternating current from an autotransformer and its temperature was regulated by a series of resistances. The electromotive force developed by the thermocouple was measured by a potentiometer. Although the area of contact between the thermocouple and the ribbon was very small it was necessarily larger than a single point. Any stray (alternating) currents from the heating circuit which might thus be caused in the thermocouple circuit were without effect on the galvanometer of the thermocouple circuit. The temperature readings from the potentiometer therefore represented true temperature readings. The wiring diagram is shown in Fig. 2.

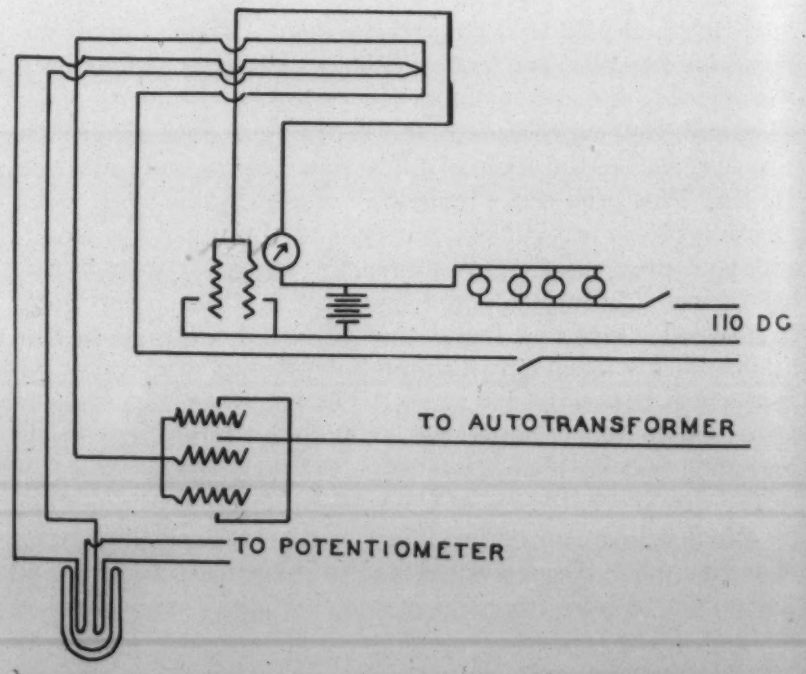

Fig. 2—Wiring Diagram of Specimen Holder and Heating Apparatus

The alumel chromel thermocouple was calibrated, using the same potentiometer as in the later work, by determining the cooling curves for chemically pure tin, zinc, aluminum and sodium chloride. The melting points of these substances were taken from the International Critical Tables. No

supercooling was observed in any case so that errors from this source were absent from the calibration. Fig. 3 shows the curve obtained from this calibration.

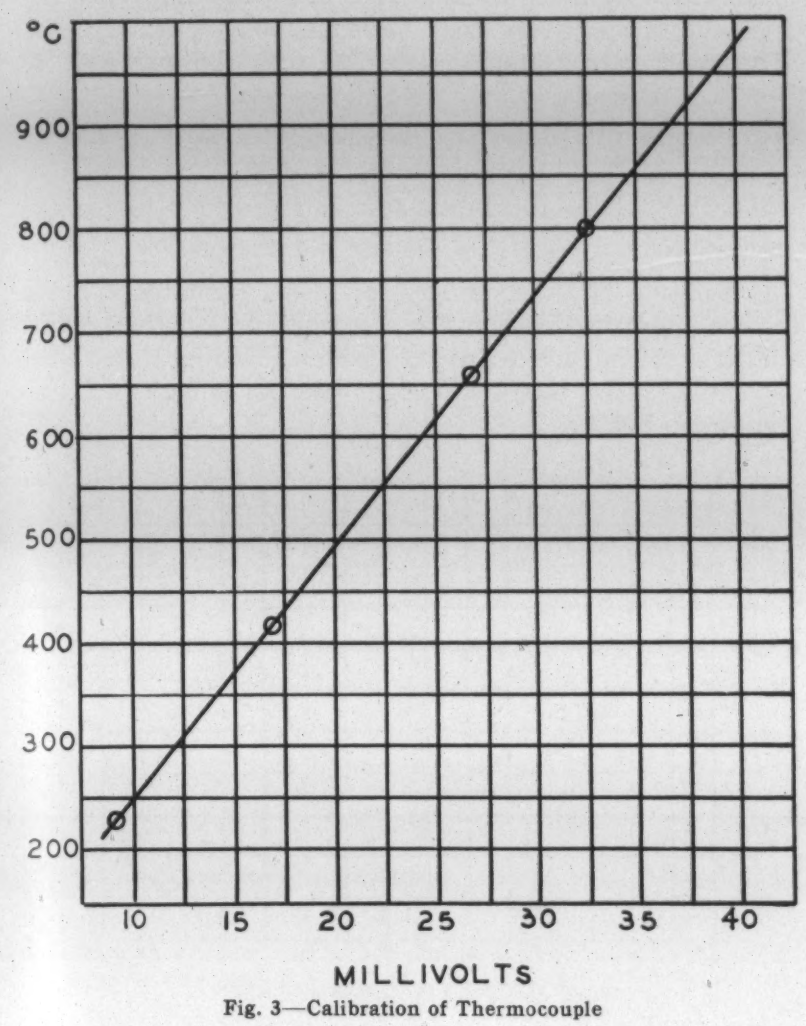

Fig. 3—Calibration of Thermocouple

The cassette was calibrated by obtaining diffraction patterns of sodium chloride and pure iron at room temperature. The distances from the undeviated beam to each of the diffracted lines were measured and plotted against the corresponding interplanar spacings as shown in Fig. 4. The data for the interplanar spacings of pure iron were taken from some earlier work of one of the authors[13] and the spacings for sodium chloride were calculated on the basis that the lattice parameter is $2.814 \cdot 10^{-8}$ cm.[13] The curve, as drawn, eliminated all of the ordinary sources of error including the eccentricities of the cassette. The analyses of the corrected patterns were made by the slide rule method.[14] The most serious sources of error which remained were in the measurements of the distances from the zero beam to the diffracted lines and the fact that the specimens were not always exactly at the center of curvature of the film. The difficulties in measuring the distances on the films were caused partly by a fuzziness of the lines due to small particle size, and partly by a curvature of the lines due to a finite length of the slits in the path of X-ray beam. The uncertainty of measuring these distances was considered to be ±0.5 mm. In case an error of 0.5 mm. were made in measuring a distance of 6.5 cm. from the zero beam an error of 0.022 A. U. would result. Thus the measurements would not decide whether the lattice parameter of a structure were 2.832 A. U. or 2.876 A. U. This difficulty in obtaining the true measurements throws out the possibility of calculating the thermal coefficient of expansion from the data and makes a slight discrepancy between the theoretical and calculated interplanar spacings. These errors were absent in the work done at room temperature, listed in Table I.

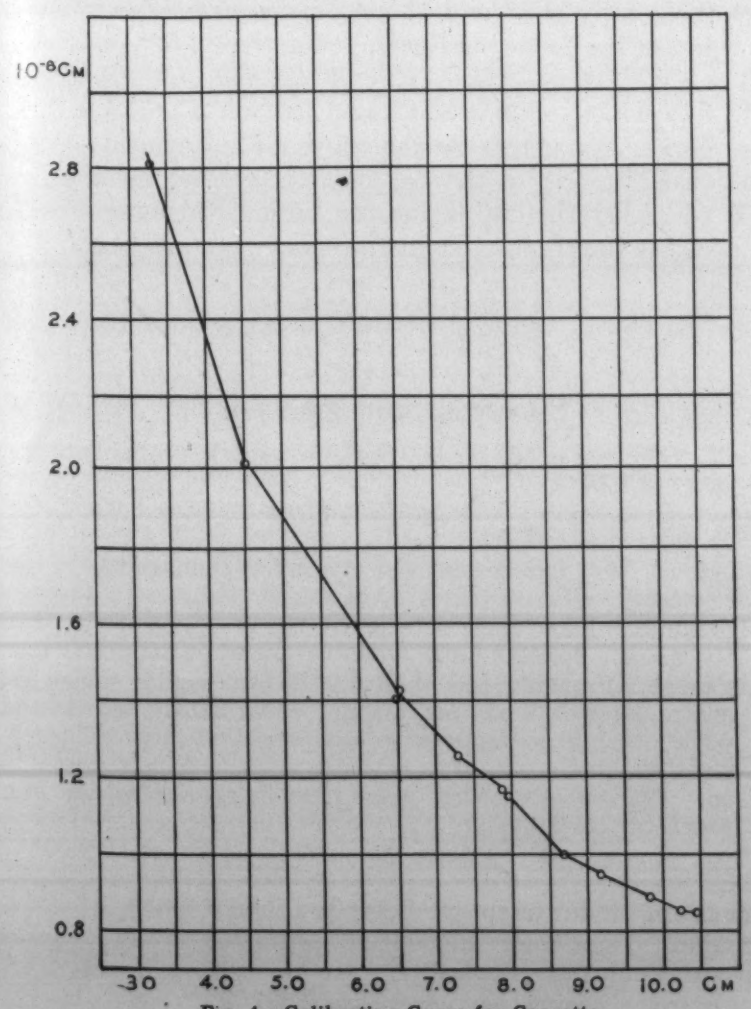

Fig. 4—Calibration Curve for Cassette

Procedure

The experimental process by means of which diffraction patterns were obtained of the specimens at the various temperatures was so simple that it was developed into a routine method. The specimens which were in wire form were cut in lengths suitable for the dimensions of the apparatus. One end of a specimen was fastened by means of a small binding post on the soapstone insulator to one wire from the storage batteries. A small tungsten weight was suspended on the other extremity of the specimen and the weight was submerged in the mercury well. The junction of the thermocouple wires was spot welded to a piece of ribbon which had the same composition as that of the wire specimen, and the ribbon was then connected to two binding posts which were the terminals of the secondary of the autotransformer. Care was used in mounting the ribbon to make sure that the spot at which the thermocouple was spot welded was at the same height as the middle of the portion of the wire which was irradiated by the X-rays. The sheet iron box was then inverted over the apparatus into the oil seal and oriented so as to admit the beam of X-rays. Hydrogen, from a tank, was allowed to enter the box and after the air in the box was completely displaced by the hydrogen, the potentiometer was set for the desired temperature. The ribbon circuit was then closed and the current was adjusted to produce the temperature for which the potentiometer was set. The specimen was then heated to the point such that a visual intensity match was obtained against the ribbon. The temperature was checked, in this way, four or five times during an exposure. The current through the specimen was checked much more frequently—usually about every half hour. The exposures ranged between 12 to 24 hours. In some cases the grain size of the specimens was so small that an exposure of 30 hours was necessary.

At room temperatures the diffraction patterns of pure iron and of the iron-nickel alloys were made on the General Electric apparatus. The value for the lattice parameter in each case was calculated by the method employed by one of the authors[13] in his work on precision methods. In brief the method was as follows: The interplanar spacings of the lines produced by the metal and by sodium chloride were measured. Using the value 2.814 A. U. for the cube edge of sodium chloride, a correction curve for each film was made and the measured spacings for the metals were corrected. Each spacing value was then multiplied by the proper structure factor so as to yield a value for the lattice parameter. These

values were plotted on probability paper and the most probable value was found from the curve.

Results

At room temperature, the lattice parameters for the alloys containing 0, 0.87, 1.04, 2.78, 4.27, 11.73 and 13.21% nickel were found to be 2.858, 2.864, 2.866, 2.851, 2.849, 2.848 and 2.846 A. U. This indicates that the first 1 or 2% of nickel produces a stretch of the iron lattice and the addition of 3% or more of nickel causes a closer packing of the atoms.

Patterns of pure iron secured at elevated temperatures show that a body-centered cubic structure exists at 907° C. and that a face-centered cubic structure exists at 910° C. The pattern at 910° C. was made from a specimen which had been heated to this temperature from room temperature. The pattern at 907° was made from a specimen after it had first been heated to 915° and then cooled to 907°. The structure at 915° C. was found to be face-centered cubic and at 907° it was found to be body-centered cubic. Evidently the structure changed from body-centered cubic to face-centered cubic and back to body-centered cubic when it was heated from room temperature to 915° C. and cooled to 907° C.

No pattern was made from a specimen which had first been heated to 910° C. and then cooled to 907° C. because this difference of 3° was the limit of accuracy of control of the apparatus. The conclusions drawn from the study of pure iron are that the A_3 point lies between 907 ± 3° C. and 910 ± 3° C. and that the change is reversible in character. We believe that the A_3 point lies between 907 and 910° C.

At the outset, the specimens were very fine grained. The lines of the patterns made from unheated specimens were fuzzy and broad. At elevated temperatures the crystal size increased markedly as evidenced by the dotted instead of continuous lines. It was observed that at 910° the specimens were weaker than at temperatures 20 or 30° higher. This decrease in tensile strength was manifested by the specimens breaking when held at this temperature during an exposure even when the tungsten weight was immersed in mercury to decrease the pull on the wire. At this temperature the body-centered and face-centered cubic structure are in equilibrium and a semi-amorphous iron can be considered to exist which represents the transient conditions of the atoms in going from one structure to another. This amorphous structure might account for the lower tensile strength of the specimens.

All the alloys used showed body-centered cubic structures at room temperature. Great care was taken with every specimen to start each heating from room temperature, so that all the data on the iron-nickel alloys reported in this paper were obtained at temperatures which had been reached *from below*. Our A_3 points for the Fe-Ni alloys are therefore all Ac_3 points. It was found that when this technique was not followed and a given temperature was reached *from above*, the face-centered cubic structure persisted over a temperature range which depended upon the nickel content of the alloy. In other words the A_3 point for the alloys is not one at which the change is reversible. The range of irreversibility was not determined. It is to be expected[15] that the temperature interval between the Ac_3 and Ar_3 points will depend on the rate of heating and the previous temperature history of the specimens but no work was done to bring this out. In such a case, it would follow that either the Ac_3 or the Ar_3 point, or both, could not represent equilibrium. We have no evidence whatever from our data of any lack of definiteness in our Ac_3 point within the precision of our temperature measurements. For instance, in the case of the alloy containing 13.21% nickel a pattern was secured at 520° which showed the presence of both face-centered and body-centered cubic structures. Another pattern secured at this same temperature (±3° C.) from the same specimen showed only the face-centered cubic structure. Therefore, if the temperature interval between Ac_3 and Ar_3 does depend upon the past history of the specimen, it must be the Ar_3 point, not the Ac_3, which represents a state of false equilibrium.

When alloys containing 1.04, 2.78, 4.27, 11.73 and 13.21% nickel were heated to 815, 715, 655, 520 and 515° C. (±3° C.) respectively they were all body-centered cubic. When they were heated to 820, 720, 660, 525 and 520° C. (±3° C.) respectively they were all face-centered cubic. We believe that the true Ac_3 points for these pure alloys are

1.04% nickel—817° ± 3° C.
2.78% nickel—717° ± 3° C.
4.27% nickel—657° ± 3° C.
11.73% nickel—523° ± 3° C.
13.21% nickel—518° ± 3° C.

The addition of the first 10% of nickel produces a much greater effect in lowering the A_3 point of iron than larger additions. The line representing this lowering versus the percentage nickel is not a straight line but is curved. This is shown in Fig. 5.

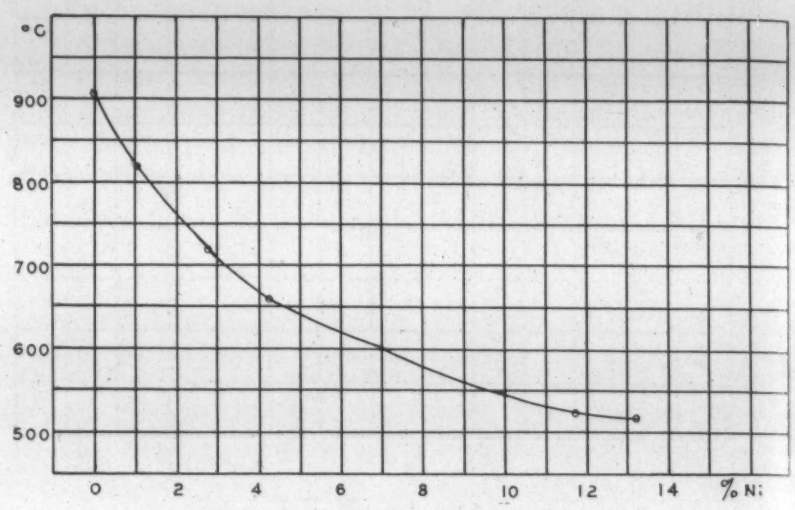

Fig. 5—Ac_3 Point for Iron-Nickel Alloys

Summary

The transition temperature at which the body-centered cubic structure of very pure iron changes to the face-centered cubic structure has been found to occur reversibly at a temperature which lies between 907 ± 3° C. and 910 ± 3° C. We believe it to lie between 907 and 910° C.

The Ac_3 points for alloys of iron and nickel containing 1.04, 2.78, 4.27, 11.73 and 13.21% nickel have been found to lie between the following limits, respectively: 820 ± 3° C.–815 ± 3° C., 720 ± 3° C.–715 ± 3° C., 660 ± 3° C.–655 ± 3° C., 525 ± 3° C.–520 ± 3° C., and 520 ± 3° C.–515 ± 3° C. The Ac_3 and Ar_3 points for the alloys do not coincide. The fractional lowering of the Ac_3 point is greater for the first 10% of nickel than it is for the larger percentages. We believe that the true Ac_3 points for these pure alloys are:

1.04% nickel — 817° ± 3° C.
2.78% nickel — 717° ± 3° C.
4.27% nickel — 657° ± 3° C.
11.73% nickel — 523° ± 3° C.
13.21% nickel — 518° ± 3° C.

Spectroscopic Analysis

Cobalt: Detected in the arc but not in the spark, probably of the order of 0.01%.

Copper: Considerably less than in an iron carrying 0.022% Cu. Estimated at 0.005%.

Chromium: Very faint trace—not over a few thousandths of one percent.

Molybdenum: Faint trace detected in the arc—not observed in the spark. No standards available—must be extremely low.

Manganese: Probably less than 0.01% but results somewhat contradictory. The "raie ultime" could hardly be detected while other lines supposedly less persistent were definitely identified in the arc.

Silicon: A trace—somewhat more than in an electrolytic iron which carries 0.005%.

Carbon: A trace—higher than the electrolytic iron with 0.005% C.

Magnesium: Faint trace—probably less than 0.0001%.

Aluminum: Faint trace—amount not estimated.

Calcium: Faint trace—0.001%.

Tin: Extremely faint trace—less than 0.001%.

Pure Iron

Distance from Zero Beam in cm.	Interplanar Spacings	Structure	Planes	Treatment
4.58	2.025	B. C. C.	110	Room
6.55	1.432		100	Temp.
7.93	1.168		210	
...	...		311	
10.25	0.905		110(2)	
4.35	2.15	F. C. C.	111	Heated to
5.10	1.82		100	950° and
7.07	1.31		110	then cooled
8.10	1.13		311	to 921°
4.60	2.05	B C. C.	110	Heated to
6.40	1.45		100	920° and
7.90	1.165		210	then cooled to 890°
4.45	2.07	B. C. C.	110	Heated to
6.30	1.45		100	920° and
7.73	1.19		210	cooled to 900°
4.40	2.12	F. C. C.	111	Heated to
5.10	1.82		100	915° from
7.20	1.28		110	room tem-
8.50	1.08		311	perature
4.55	2.025	B. C. C.	110	Heated to
6.37	1.46		100	915° and
7.87	1.17		210	cooled to 907°
4.40	2.12	F. C. C.	111	Heated to
5.10	1.82		100	910° from
7.20	1.28		110	room tem- perature

Iron-Nickel (11.73% Ni)
Heated from room temperature

Distance from Zero Beam in cm.	Interplanar Spacings	Structure	Planes	Treatment
4.25	2.215	F. C. C.	111	Heated to
4.93	1.88		100	600°
...	...		110	
...	...		311	
8.32	1.085		111(2)	
4.50	2.05	B. C. C.	110	Heated to
...	...		100	500°
7.85	1.175		210	
4.40	2.12	B. C. C.	110	Heated to
5.50	1.855		100	550°
4.40	2.12	F. C. C.	111	Heated to
5.10	1.82		100	525°
7.20	1.28		110	
4.50	2.05	B. C. C.	110	Heated to
...	...		100	510°
7.90	1.165		210	
...	...			
4.50	2.05	B. C. C.	110	Heated to
...	...		100	515°
7.90	1.165		210	
			311	
11.25	0.830		100(2)	
4.50	2.05	B. C. C.	110	Heated to
...	...		100	520°
7.90	1.165		210	
...	...		311	
11.25	0.830		100(2)	

Iron-Nickel (13.21% Ni)
Heated from room temperature

Distance from Zero Beam in cm.	Interplanar Spacings in A°	Structure	Planes	Treatment
4.58	2.00	B. C. C.	110	Heated to
6.50	1.428		100	480°
4.40	2.12	F. C. C.	111	Heated to
5.10	4.82		100	525°
7.25	1.273		110	
4.55	2.025	B. C. C.	110	Heated to
6.40	1.45		100	500°
8.00	1.15		210	
4.55	2.025	B. C. C.	110	Heated to
6.37	1.46		100	510°
		F. C. C. and B. C. C.		
...	...	F. C. C.	111	Heated to
4.40	2.12	F. C. C.	100	520°
4.60	1.99	B. C. C.	110	
6.10	1.52	F. C. C.	110	
6.50	1.425	B. C. C.	100	
7.20	1.280	F. C. C.	311	
7.95	1.160	B. C. C.	210	
4.43	2.10	F. C. C.	111	Heated to
5.03	1.845		100	520°
7.10	1.30		110	
...	...		311	
8.50	1.042		111(2)	

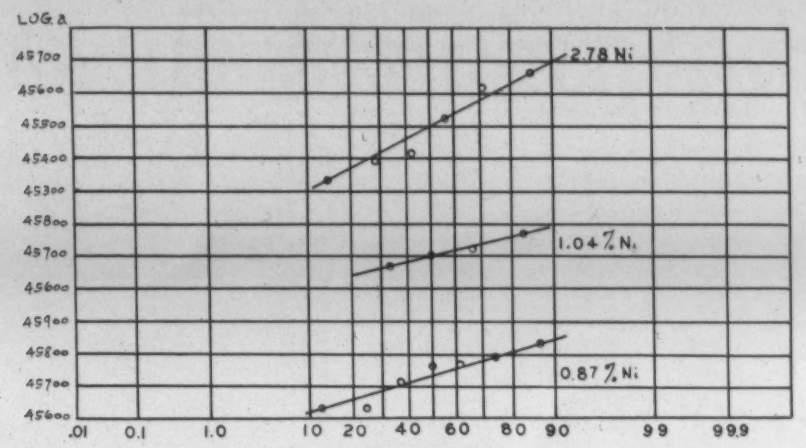

Fig. 6a

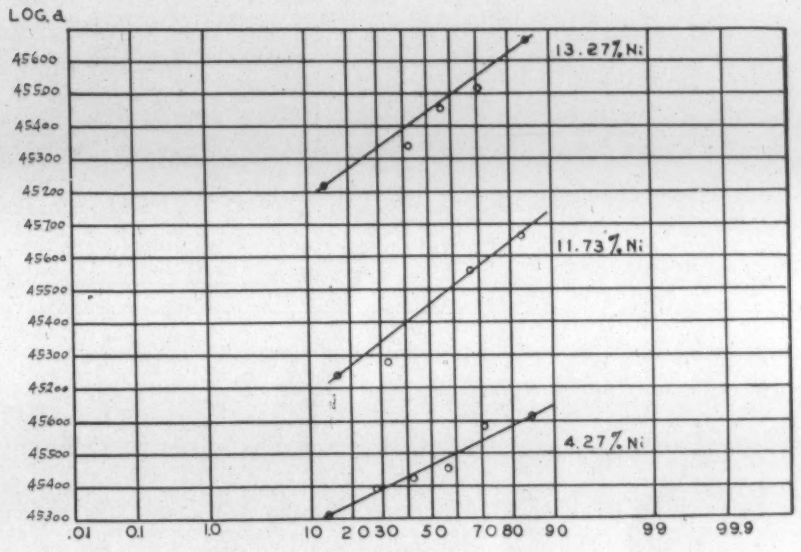

Fig. 6b

Fig. 6—(a) Graphical Solutions for Most Probable Values of the (b) Lattice Parameters of Iron-Nickel Alloys at Room Temperature

Iron-Nickel (1.05% Ni)
Heated from room temperature

Distance from Zero Beam in cm.	Interplanar Spacings	Structure	Planes	Treatment
4.40	2.12	F. C. C.	111	Heated to
5.10	1.82		100	900°
7.20	1.28		110	
4.50	2.05	B. C. C.	110	Heated to
6.30	1.47		100	800°
7.80	1.18		210	
4.35	2.15	F. C. C.	111	Heated to
5.05	1.835		100	850°
7.15	1.30		110	
4.40	2.12	F. C. C.	111	Heated to
5.10	1.82		100	825°
7.20	1.28		110	
...	...		311	
8.45	1.05		111(2)	
4.47	2.07	B. C. C.	110	Heated to
6.45	1.485		100	815°
7.75	1.19		210	
4.38	2.13	F. C. C.	111	Heated to
5.08	1.83		100	820°
7.17	1.29		110	
...	...		311	
8.45	1.05		111(2)	

Iron-Nickel (4.27% Ni)
Heated from room temperature

Distance from Zero Beam in cm.	Interplanar Spacings	Structure	Planes	Treatment
4.43	2.1	F. C. C.	111	Heated to
5.13	1.81		100	680°
7.2	1.28		110	
4.58	2.0	B. C. C.	110	Heated to
...	...		100	580°
7.89	1.167		210	
4.55	2.025	B. C. C.	110	Heated to
6.35	1.42		100	630°
7.95	1.16		210	
4.4	2.12	F. C. C.	111	Heated to
5.1	1.82		100	660°
4.55	2.02	B. C. C.	110	Heated to
...	...		100	650°
7.9	1.168		210	
4.55	2.02	B. C. C.	110	Heated to
...	...		100	650°
7.9	1.168		210	

Iron-Nickel (2.78% Ni)
Heated from room temperature

Distance from Zero Beam in cm.	Interplanar Spacings in A°	Structure	Planes	Treatment
4.45	2.09	F. C. C.	111	Heated to
5.10	1.82		100	750°
7.20	1.28		110	
...	...		311	
8.46	1.05		111_2	
4.50	2.05	B. C. C.	110	Heated to
6.40	1.45		100	700°
7.85	1.175		210	
4.50	2.06	F. C. C.	111	Heated to
5.20	1.79		100	725°
7.20	1.28		110	
8.10	1.128		311	
8.50	1.042		111_2	
4.50	2.05	B. C. C.	110	Heated to
6.40	1.45		100	715°
7.80	1.182		210	
4.45	2.09	F. C. C.	111	Heated to
			100	720°
5.15	1.80		110	
7.25	1.275		311	
...	...		111_2	
8.65	1.01			

Iron and Iron-Nickel Alloys—Room Temperature
Body-Centered Cubic
Interplanar Spacings. (G. E. Apparatus)

Plane	Percent Nickel					
	0.87	1.04	2.78	4.27	11.73	13.21
110	2.04	2.04	2.00	2.00	1.99	1.99
100	1.435	1.432	1.420	1.493	1.417	1.416
211	1.176	1.171	1.161	1.159	1.158	1.159
110_2	1.016	1.013	1.006	1.010	1.007	1.007
310	0.907	0.905	0.902	0.904	0.903	0.902
111	0.827	...	0.826	0.821	...	0.820
321	0.764	0.761	0.764	0.762	0.765	0.765
100_2 / 411	...	...	...	...	...	...
110_2	0.674	...	...	...	...	...
a*	2.864	2.866	2.851	2.849	2.848	2.846

* Side of unit cube.

Bibliography

1 Osmond, *Contributions á l'étude des Alliages*, Paris (1901), page 277.
2 Roberts-Austin, *Proceedings Institution of Mechanical Engineers*, Vol. 52 (1897), page 31; Vol. 56 (1899), page 35.
3 LeChatelier, *Revue générale des Sciences*, Vol. 8 (1897), page 11.
4 Burgess & Crowe, *Bulletin American Institute of Mining & Metallurgical Engineers*, No. 82 (1913), page 2537.
5 Hanson & Hanson, *Journal Iron & Steel Institute*, Vol. 102 (1920), page 39.
6 Hull, *Physical Review*, Vol. 10 (1917), page 681.
7 Hull, *Physical Review*, Vol. 17 (1921), page 577.
8 Andrews, *Physical Review*, Vol. 18 (1921), page 245.
9 Westgren, *Journal Iron & Steel Institute*, Vol. 103 (1921), page 302.
10 Westgren and Phragmen, *Journal Iron & Steel Institute*, Vol. 105 (1922), page 241.
11 McKeehan, *Physical Review*, Vol. 21 (1923), page 402.
12 Osawa, *Journal Iron & Steel Institute*, Vol. 113 (1926), page 448.
13 Davey, *Physical Review*, Vol. 25 (1925), page 753.
14 Davey, *General Electric Review*, Vol. 28 (1925), page 593.
15 Saveur, *The Metallography and Heat Treatment of Iron and Steel*, New York (1926), page 93.

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We are deeply indebted to the General Electric Company for making available certain equipment without which this work would have been very difficult or even impossible. We are greatly indebted to Mr. Floyd C. Kelley of the General Electric Research Laboratory for the preparation of our specimens and for the meticulous care which avoided the introduction of impurities. We are also indebted to Mr. C. C. Nitchie of the New Jersey Zinc Company for his kindness in making the spectroscopic analysis of a typical specimen from our alloys.

Tube-Turns, Inc., Louisville, Ky., recently completed plant and equipment additions which will increase their production 60%. This expansion was made necessary to take care of the ever-increasing demand for Tube-Turns fittings which ran 271% ahead of 1929 for the first five-month period.

Arthur K. Mitchell, until recently assistant to the president of St. Joseph Lead Co., died at his home in Bronxville, N. Y., on May 5. In 1920 he invented the Mitchell underground shovel, which was adopted by St. Joseph and several other mining companies. Mr. Mitchell was 46 years old.

The Prest-O-Lite Company, Inc., has placed in operation a new dissolved acetylene plant at 648 Bryan Stock Trail, Casper, Wyo.

World Reserves of Tin and United States Consumption

Tin has become more and more indispensable to American industry in recent years, states Charles White Merrill, in a report prepared by the Common Metals Division of the Bureau of Mines. The canning and automobile industries, the outstanding consumers of tin and its alloys, have grown so great that over 40% of the world's virgin tin production is consumed in the United States. Over 99% of the virgin tin required for domestic purposes is imported from foreign sources. Domestic production of virgin tin has always been so small as to be negligible, and long-continued search has failed to reveal tin resources which will be available in the future at present or considerably higher prices. Only by the recovery of tin from scrap has the United States succeeded in supplying any appreciable portion of its requirements.

It seems probable that the United States will remain dependent upon foreign production for its future supply of virgin tin. For this reason the tin resources of the world, including the tin reserves of producing companies, are of very vital interest to American tin consumers. Upon knowledge of resources and reserves must depend the stabilizing of metal prices.

In 1928 the Federated Malay States was the largest producer of tin in the world. Of the production of 61,935 long tons, 51% was derived from Chinese-operated mines. The lack of data on reserves of the Chinese-owned mines makes a forecast of the future tin production of the Federated Malay States exceedingly difficult. Undoubtedly, however, Chinese-owned reserves are sufficient for some time to come.

Of a total European-operated dredge production of 18,750 tons in the Federated Malay States, 7866 tons came from properties reporting reserves. These reserves if exploited at the 1928 rate assure a life of 28 years to the group of reporting companies without additional developments or discoveries. Many of the dredging companies are undoubtedly nearly worked out both in respect to ore and serviceability of equipment; but others are developing further reserves. In addition to the operating areas there are alluvial tracts already proved to contain over 170,000 tons of tin available at present prices. Since most of this reserve is to be exploited by dredging it should require at least 20 years to work out and should contribute 5000 to 10,000 tons of tin a year in the near future.

During 1928 Bolivia contributed 41,409 tons of tin to world production. Practically all this tin was extracted from lode deposits. Over 23,548 tons came from mines for which reserve figures are available. These reserves assure the mines reporting them an average life of $5^1/_2$ years at the present rate of production. Though $5^1/_2$ years' reserves would amount to very little in alluvial areas, it indicates a very healthy condition when reported for lode deposits.

No definite figures are available on the reserves of the Netherland East Indies, though its production of 36,600 tons of tin in 1928 placed it third among world tin producers. Much of the tin is won by various open-pit methods which do not require the proof of reserves before exploitation. The improvement of mining methods and the possible development of lode deposits in the Netherland East Indies may prolong the life of this area well beyond the 10 or 12 years of the high-grade alluvial areas.

Nigeria produced 9100 tons of tin during 1928, almost wholly from alluvial deposits. Siam produced 7900 tons of tin in 1928, of which 1299 tons came from operations reporting reserves. The reserves of nonproducers stood at the high figure of 40,328 tons, which would indicate a future expansion for Siam. The production of Siam is practically all from alluvial deposits, and most of the nonproducing reserves either have dredges under construction or are endeavoring to finance dredge operations.

China is estimated to have produced 7033 tons of tin during 1928. Though there are no reserve figures available for the Chinese deposits, the fact that much of the production comes from lodes and residual material at the outcrops of lodes, leads to the belief that China's production of tin should increase rather than decrease.

During 1928 Australia produced 2900 tons of tin, 211 tons of which came from mines reporting reserves. The reserves of these producers assured an average life of $12^1/_2$ years at the present rate of production. Nonproducers reported reserves of 7000 tons of tin. The tin producing areas of Australia are widely scattered and include both lode and placer deposits. There are great reserves of very low-grade disseminated tin ore which should become available with an advance in mining methods or an increase in the price of tin.

During 1928, 2782 tons of tin was produced in the Cornwall district in England.

The province of Burma, India, produced 2200 tons of tin during 1928. Of this production 1048 tons came from properties reporting reserves. Properties not yet in production reported

(*Continued on Page 673*)

New Etching Reagent for the Macrography of Aluminum and Its Alloys

By C. M. Tucker*

Macro-etching to reveal grain structure and the presence of defects is recognized as most useful in steel, and is being applied more and more to copper-base alloys. This article describes an improved macro-etch for aluminum alloys. It is well known that grain size affects the properties of aluminum alloys to an important degree. A non-destructive method of examination is always of interest. Besides its utility as an inspection method, it opens up interesting decorative possibilities.

Macrography of aluminum and its alloys presents certain difficulties, the majority of which have been removed through the development in the past years of suitable reagents and technique.

Probably two of the first etches used for aluminum and its alloys were aqueous or alcoholic solutions of sodium hydroxide or hydrofluoric acid, but these were not entirely satisfactory and gave indifferent results. Hanson and Archbutt[1] describe these solutions in the following manner: "These two reagents give fairly satisfactory results, but they sometimes produce badly tarnished surfaces from which the surface deposit is difficult to remove." Although these etches were discarded for use in the laboratory, aqueous solutions of sodium hydroxide have a wide application as a commercial pickling reagent.

Fulton B. Flick[2] developed an etch which was a considerable improvement over the above solutions. This reagent consisted of a solution containing 9% HF and 13% HCl and was used rather successfully for laboratory and experimental work.

In recent years the technique of preparing metallographic specimens of aluminum and its alloys has been materially improved. Coincident with the progress in polishing is the development of various etching solutions. E. H. Dix, Jr., has played a prominent part in the recent advance in these two fields. E. H. Dix, Jr., and F. Keller[3] recommend an aqueous solution of 1% HF, 1.5% HCl and 2.5% HNO_3 for etching aluminum-copper alloys.

The solutions that have been developed and are now in use give excellent results on highly polished and carefully prepared specimens. In many cases where there is considerable surface flow or disorganized material due to machining operations, a deep etch is essential. Most of the known reagents produce excessive pitting upon prolonged attack.

Until a few years ago, high purity aluminum, 99.9+%, resisted all efforts to reveal its structure in a rapid and satisfactory manner. The etches that are now used also necessitate a long etching time.

There was no solution available that gave a satisfactory etch on a machined surface. This lack of a suitable reagent has been rather unfortunate because very frequently it is desirable to examine the grain size of fabricated products in the machined condition.

With the possible exception of NaOH followed by HNO_3 there were no etching solutions that would produce a good etch on an as-cast surface. At the present time the U. S. Aluminum Company pickles many finished products in an aqueous solution of NaOH followed with a rinse in HNO_3. There are two practical disadvantages of such an etch. The first is the use of two solutions, and the second the extreme pitting tendency of NaOH.

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[1] "The Micrography of Aluminum and Its Alloys," *Journal Institute of Metals*, Vol. 21, 1919, pages 291–318.

[2] "Etching Aluminum and Its Alloys for Macrographic and Microscopic Examination," *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 71, 1925, page 816.

[3] "An Etching Reagent for Aluminum-Copper Alloys," *Mining and Metallurgy*, Vol. 9, July 1928, page 327.

Recently, however, an etch has been developed in the laboratories of the Aluminum Company of America which has overcome a number of the above objections. The new solution has the following composition:

Conc. HCl, Sp. Gr. 1.18	45%
Conc. HNO_3, Sp. Gr. 1.42	15%
Conc. HF Sp. Gr. 1.15	15%
Warm H_2O	25%

In order to satisfactorily etch aluminum or an aluminum alloy where the surface has been prepared by rough machining

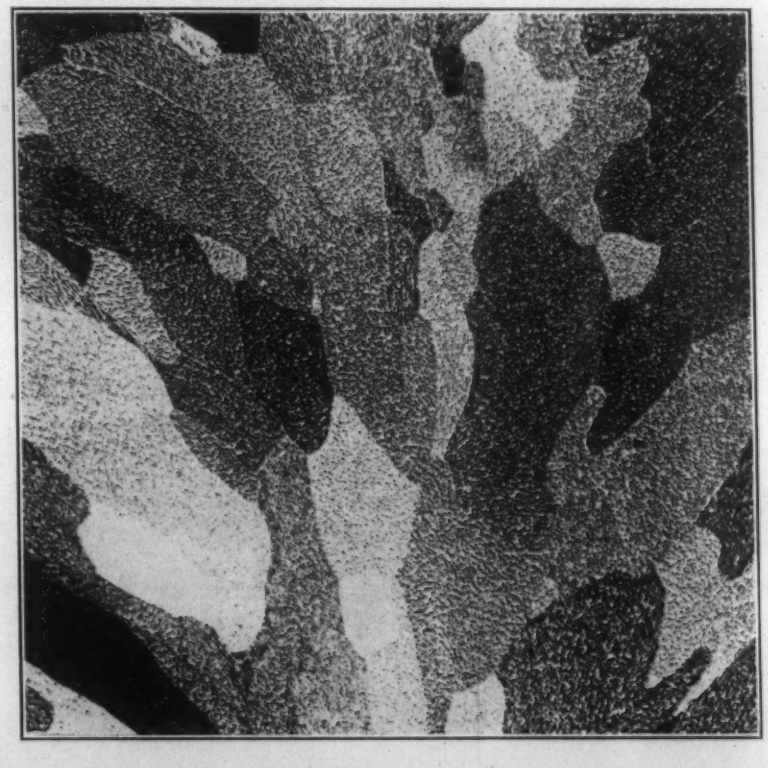


Fig. 1—Chill Cast Specimen of 99.9+ % Aluminum, × 6

or with coarse emery paper, the following technique should be employed. The surface should be entirely clean of any oil or grease deposited from the machining operation. Carbon tetrachloride is very good for this purpose. In order that the etching reagent may attack the material uniformly it is essential that the solution be applied quickly and evenly over the area to be examined. As soon as the reaction begins and during the entire process swab vigorously so that any film forming over the grains will be removed. When swabbing is omitted, cleanliness and contrast of the etch are materially reduced. After the desired contrast has been attained, the sample is washed with warm water and dried. The new solution etches uniformly and has little tendency to form large pits on prolonged etching.

If the above procedure is followed closely, good etches can be obtained. Nevertheless, occasional variations may be noted from alloy to alloy and between samples of the same composition. The etch may appear too dark or too white causing it to have insufficient contrast to be photographed. When too dark, increase the percentage of HNO_3 in the solution, but when the etch is too white this condition may be due to either too much HNO_3 or not sufficient HF.

It will be noted that the reagent is made up with warm

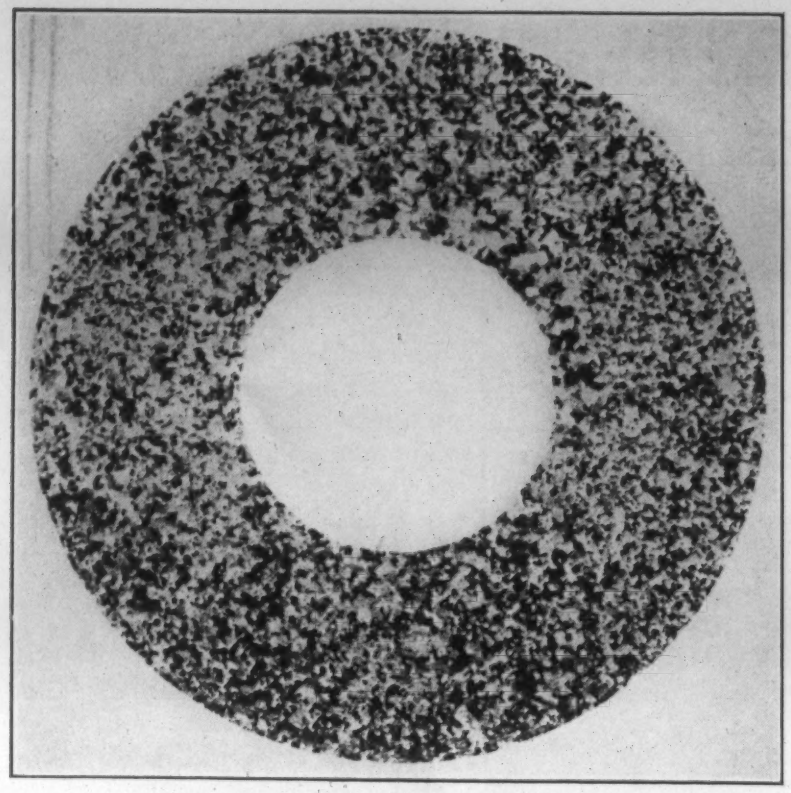


Fig. 2—Heat-Treated Sand-Cast 195 Alloy Casting, × 1

water. This does not seem to affect the quality of the etch and considerably speeds the reaction. Greater action can be obtained by increasing the hydrochloric acid content, but this is not advisable because the contrast is reduced.

A sample of high purity aluminum, 99.9+, was taken through the first stage of polishing and etched with the new reagent. A macrophotograph is shown in Fig. 1. The macrostructure is clear, sharply defined, and possesses excellent contrast. Interesting etching figures within the grains are apparent.

Fig. 2 shows a heat-treated 195[4] alloy sand casting. The surface was prepared on coarse emery paper. A moderately fine-grained structure was clearly revealed and with high contrast.

[4] For brevity, Aluminum Company of America alloy numbers will be used in this paper. Compositions are as follows:

195—4% Cu alloy used for heat-treated castings
122—10% Cu, 1.25% Fe, 0.25% Mg
25S—4.4% Cu, 0.8% Si, 0.75% Mn
17S—4.0% Cu, 0.5% Mg, 0.5% Mn
51S—1.0% Si, 0.6% Mg

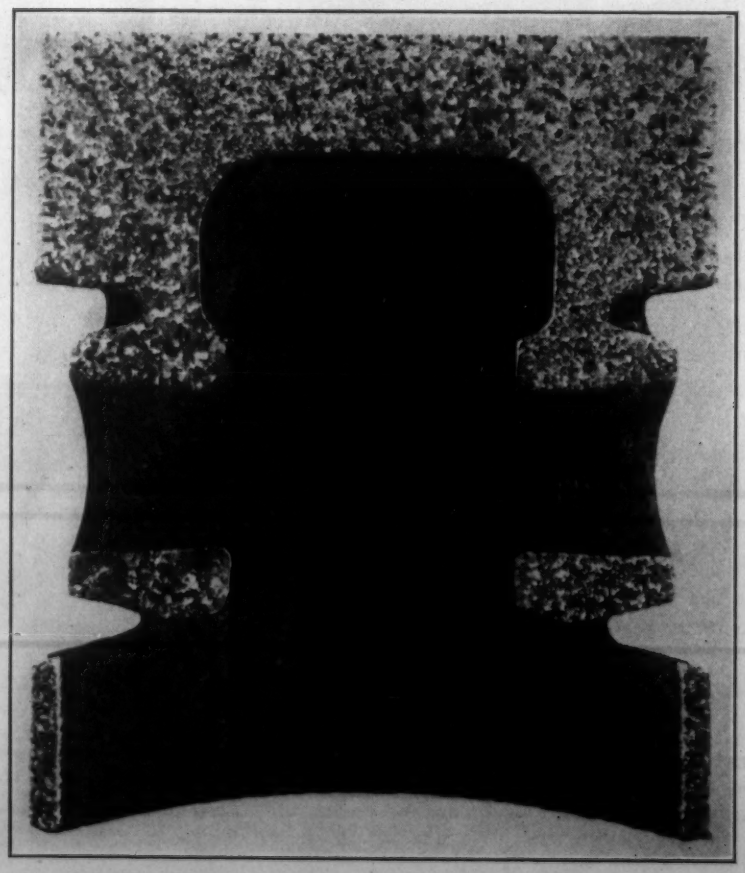


Fig. 3—Machined Section of 122 Alloy Piston, × 1

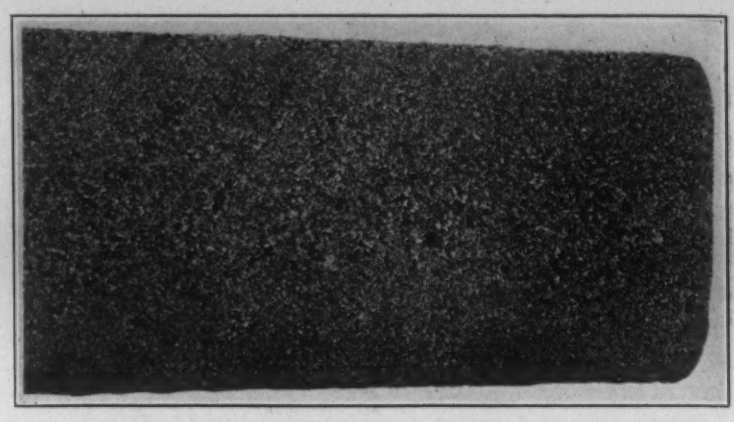


Fig. 4—Machined Section of an As-Cast 25S Ingot, × 1, (Reduced 1/2)

Fig. 3 is a machined section of an as-cast permanent mold 122 alloy piston showing distinctly a fine-grained structure. The surface was prepared on coarse emery paper.

The new solution has been used for etching machined surfaces of ingots. The following alloys, 25S, 17S, 51S, have been successfully etched.

Fig. 4 is a section of a 25S ingot showing clearly a sound, fine-grain structure. It is difficult to etch fine polycrystalline material and also material in the as-cast condition with sufficient contrast to distinguish the different grains.

Fig. 5 illustrates another interesting application of the new reagent. The rough surface of an as-cast 122 alloy permanent mold piston was etched and a clear, sharp macrostructure obtained. The grains are also visible on the rough fracture of the gate at the sides of the piston. These etched surfaces present a very pleasing appearance and offer decorative possibilities for architectural and other ornamental castings.

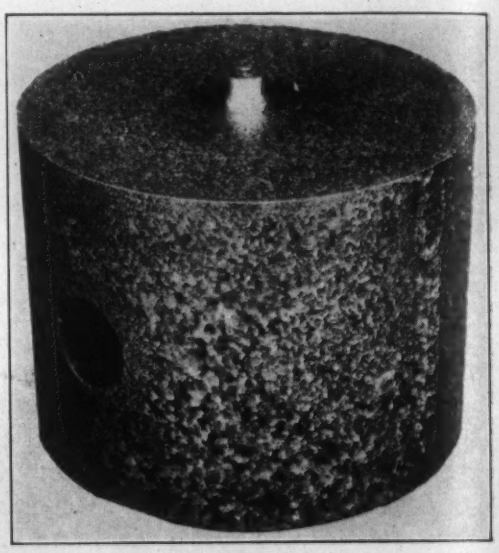


Fig. 5—As-Cast 122 Alloy Piston, × 1 (Reduced 1/2). Etched without Any Special Preparation of Surface

The ability to produce good etches on an unprepared surface affords a cheap and excellent method of checking the macrostructure of fabricated products.

Kuno B. Heberlein died suddenly in London on June 1. He was born in Switzerland in 1874, and was a graduate of the University of Basle, with the degree of Ph.D. He was a citizen of the United States, and spent a large part of his life in this country. He was connected with the development of the Huntington-Heberlein pot-roasting process and the Harriss lead refining process, which he also introduced in this country. Until 1921 Dr. Heberlein was Vice-president of American Metal and president and general manager of Penoles Mining, Mexican subsidiary of American Metal. He was also at one time president of the Metallurgical & Chemical Corporation, and had extensive mining interests in Europe, Australia and South America. During the last two years Dr. Heberlein lived in London.

After August 1, 1930, the firm of Skinner, Sherman & Esselen, Inc., will become Skinner & Sherman, Inc., Dr. G. J. Esselen having withdrawn by mutual consent. Recently this organization has extended its activities by combining the consulting engineering practice of Mr. Frederic C. Clark of South Manchester, Connecticut, with its own business. Mr. Clark has had a broad and varied experience and is well known especially in the pulp and paper industry. Mr. Burton G. Philbrick, who for many years has been in charge of the bacteriological department, and Mr. Clark have been elected Vice-presidents; and Mr. Wilder A. Chapman, in charge of analytical and metallurgical work, has been elected Secretary.

The Uses of Nickel Brasses*

By Sherwood B. Seeley[1]

A close study of some of the present well-known special brasses containing nickel reveals a series of alloys which are bewildering in their complexities and one can only hazard a guess at the function and commercial value of each of the many elements used. This article is not intended to include them all; only those whose compositions are about 60% copper, 5–30% nickel, and the remainder zinc will be treated here—an exception being made for the alloys containing small amounts of lead.

To review the types of nickel brasses (nickel silver) that come within the class just mentioned, it is better first to describe them and mention the use to which each is put, for the mixture is varied to suit the use. The color of nickel brass is almost entirely dependent upon the amount of nickel present, the copper content not being an important factor in this property. Nickel brasses are generally named by their nickel content, the commonest alloy being the 18% which is silvery white. From 18–25% Ni, the color changes slightly, until at 30% Ni the alloy has a slight bluish luster. The 15% nickel brass cannot readily be distinguished from the 18%, except by close comparison; the 15% alloy being slightly tinged with yellow. At 10% nickel the alloy shows an appreciable difference when placed beside the 18% metal, but anyone not well acquainted with these alloys would hardly perceive a difference unless they were placed side by side. When the nickel content reaches as low as 5%, the alloy has the appearance of a very light-colored brass—almost white. The appealing luster and fine texture of nickel brass immediately suggests it as an ornamental alloy. For this use it usually contains about 60% copper, 18% nickel and the remainder zinc. But here, again, the mixture will vary slightly for the use. Urns, vases and articles of similar cup-like formation require more copper in their composition than flat sheets. The additional copper is needed because cups require more working than sheets, and the more copper a nickel brass contains, the greater its ductility. Perhaps the most common use to which nickel brass is put is in the manufacture of knives, forks and spoons. Here the nickel content runs from 10–25%. The majority, however, are from 10–18%. The lower-nickel alloys are used because they are cheaper than those of 18%.

To the work just mentioned, nickel brasses are admirably adapted because of their property of receiving and retaining a smooth plating of silver. The plate does not peel and, because nickel brasses are of practically the same color and texture as silver, the plating can be thin. Plain brass would require a heavy plating of silver because the yellow color would show wherever the plating wore off. For this reason, silver-plated brass spoons are not manufactured extensively. Sterling silver tableware bends readily and is more easily marred in use than the harder nickel brass. Therefore it is more practical to plate nickel brass, and while the finished ware is cheaper than silver, it is really more serviceable. Of course, the controlling factor in practice is the difference in cost. Cheaper grades of tableware are made from the alloy itself. It is given a high polish and no plating is used. The cases of many low-priced watches are made of this alloy. It costs more than brass, but when the nickel plate wears off there is no ugly tell-tale yellow smear to give away the fact that the watch is a cheap one. Where brass would tarnish readily, rustless equipment in bathrooms, cafes, boats and automobiles is made of this alloy.

Nickel brass is drawn and stamped in the same manner as is steel. Trays, dish-holders, milking-machine parts and dairy equipment in general, automobile hub-caps and trimmings are all stamped from this alloy. It is rolled into long sheets up to 40 inches in width and finished in smooth rolls followed by a high polish.

Another commercial product that requires large quantities of nickel brass is wire. The alloy is ductile enough for drawing but because of its stiffness more power is required to work it than is needed for brass. This wire is very strong (hard-drawn nickel-brass wire can be made with a tensile strength of 150,000 lbs./in.^{2}) and is put to many uses. It produces excellent rustless rivets, cutlery points and other things where a combination of strength and appearance are needed. Most mesh bags upon examination will be found to be made of nickel brass wire. Optical goods also use large amounts in their manufacture. Perhaps the greatest single use to-day to which nickel brass wire is put is the manufacture of the gaiter-fastener. Arctics, overalls, working shirts and tobacco pouches are familiar articles which have similar fasteners, and their use is steadily increasing. A wire known commercially as resistance wire is a low-copper alloy—being about 55% copper; the nickel varies from 15–30%. This wire shows a specific resistance of about twice the resistance of platinum. Thirty percent nickel brass is sometimes drawn to 0.001 inch for use in electrical instruments.

Not only wire but seamless tubing and shells as well can be drawn from nickel brasses. The tubes are made from 3 feet in diameter down to a few thousandths of an inch. The large cylinders are used in ice-cream freezers and the small tubes are made into bead-chains for electric pull-switches. All sizes from one-half inch up are used in dairy equipment.

A still different type of nickel brass is that containing lead. This metal does not alloy with the brass appreciably but separates out along the crystal boundaries; and although it can be rolled very hard, it is easily machined, because of the lead which causes the chips to break. The lead content may run as high as 2%, though usually the alloy contains only about 1%. The composition of leaded stock is essentially the same as other nickel brasses, the lead replacing some of the zinc. The fact that this alloy does not rust and is easily machined, combined with its strength and pleasing appearance, makes it well suited for the manufacture of keys. In fact, all the better grades of flat keys to-day are made from this alloy. Of course, the higher the grade of alloy that is used, the smaller the keys can be made. This makes them more convenient to carry and is readily appreciated by those who must carry a large number of keys about. Because of this use, rolled, leaded-nickel brass is known as key-stock. Rods are likewise made from this alloy and since they are readily machined, they are used in automatic screw-machines.

The nickel brasses are melted in crucibles or electric furnaces. The molten metal is then cast into iron molds which have been smeared on the inside with a mixture of graphite and oil.

After the bars are cropped they go directly to the breaking-down rolls; only in special cases where an extremely fine grain is desired are they first annealed. After a few passes through the rolls the bars are annealed, straightened and placed upon a machine which shaves the surface of the bars and removes any defects which might have been produced in the casting operation. Only in the case of a high-copper alloy (70–80% copper) or an alloy low in copper (40% copper and 10–15% nickel) is it hot-rolled, and these exceptions are so rare that they may be omitted. After the surface is freed from defects the metal goes through a series of rollings with intermediate anneals. These anneals are necessary to soften the metal because it hardens rapidly under cold working, the annealing temperature being about 800° C. In fact, nickel brass behaves much the same as brass except that more power is required to drive the rolls.

After each anneal, the metal must be pickled to remove the scale formed by the oxidation of the metal. If the scale were not removed, it would be rolled into the surface and produce defects which would show up when the metal was cleaned.

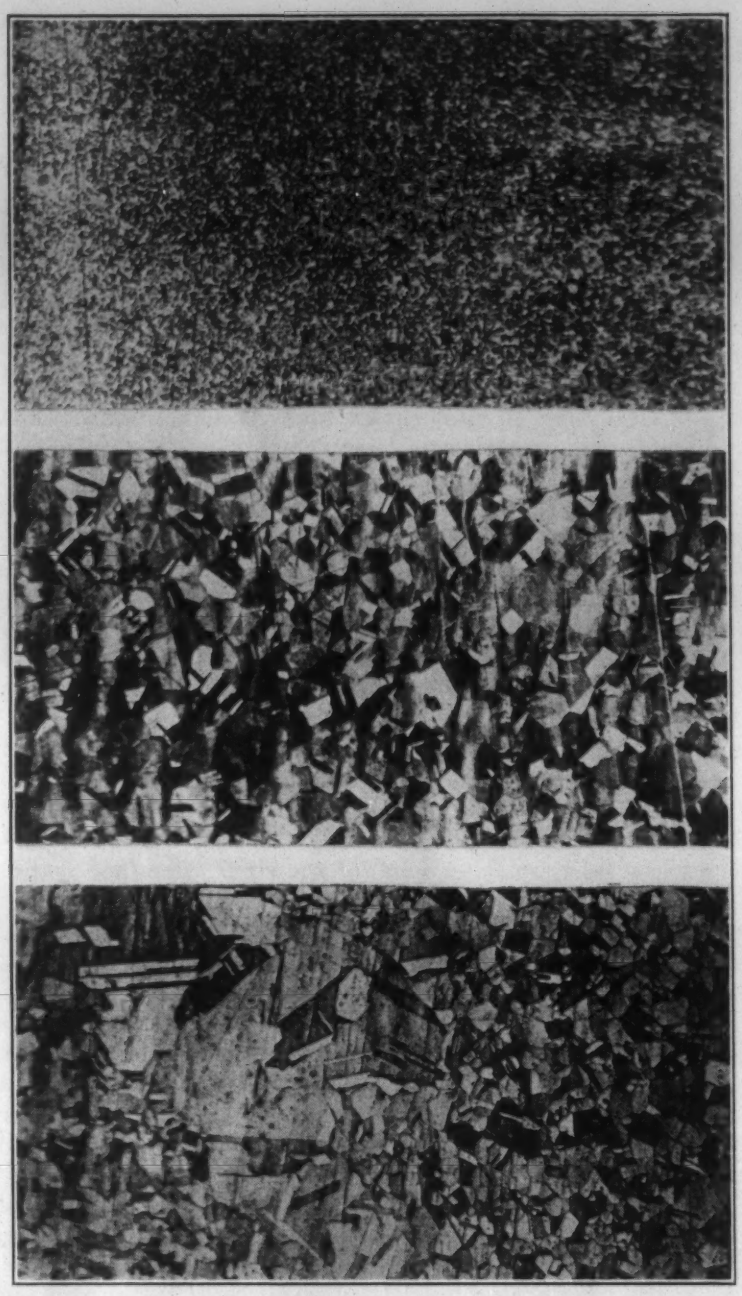
When wire is to be the finished product, the alloy is cast into rods about 8 feet long and from $1^1/_2$–2 inches in diameter. They are rolled down small enough to be drawn through a bull-block, a large machine which draws the rods through a heavy steel die and coils them. After passing the bull-block, the wire is drawn through successive sizes of steel dies down to 0.050 inch in diameter. Wire smaller than this is drawn through a diamond die. Wire is annealed and pickled in the same manner as are the bars.

Nickel brasses are spun by hand with frequent annealing. Ten percent nickel brass is used largely because it is easier to work, but many manufacturers prefer the 18% alloy because it produces a stiffer finished article and is superior in color to the lower-nickel alloys. Nickel brass can be extruded hot through dies, but it is not often worked by this operation, for the dies will not stand up for long under the strain.

An interesting point about nickel brasses is a transformation that occurs on heating the alloy of about 60% copper content to a point below its annealing temperature. At a particular temperature, depending upon the composition, a re-orientation of the

* Adapted from Vogelstein Prize Essay.

[1] Chemical Engineering Senior, New York University.



18% Nickel Brass: Cu 65%, Ni 18%, Zn 17%. Magnification 75 ×

Sample: Fig. 1.

Etching Reagent: Conc. $NH_4OH + 3\%$ H_2O_2.

Treatment: Alternate heavy mechanical working and annealing, final anneal below 600° C.

Remarks: Scleroscope hardness 26. It is homogeneous, the cored structure having been destroyed by mechanical work and heat treatment.

Use: Takes a high polish and is suited for very light working.

Sample: Fig. 2.

Etching Reagent: Electrolytic using $K_2Cr_2O_7$.

Treatment: Rolling with light anneals.

Remarks: The parallel ridges indicate insufficient working to completely destroy the dendritic structure.

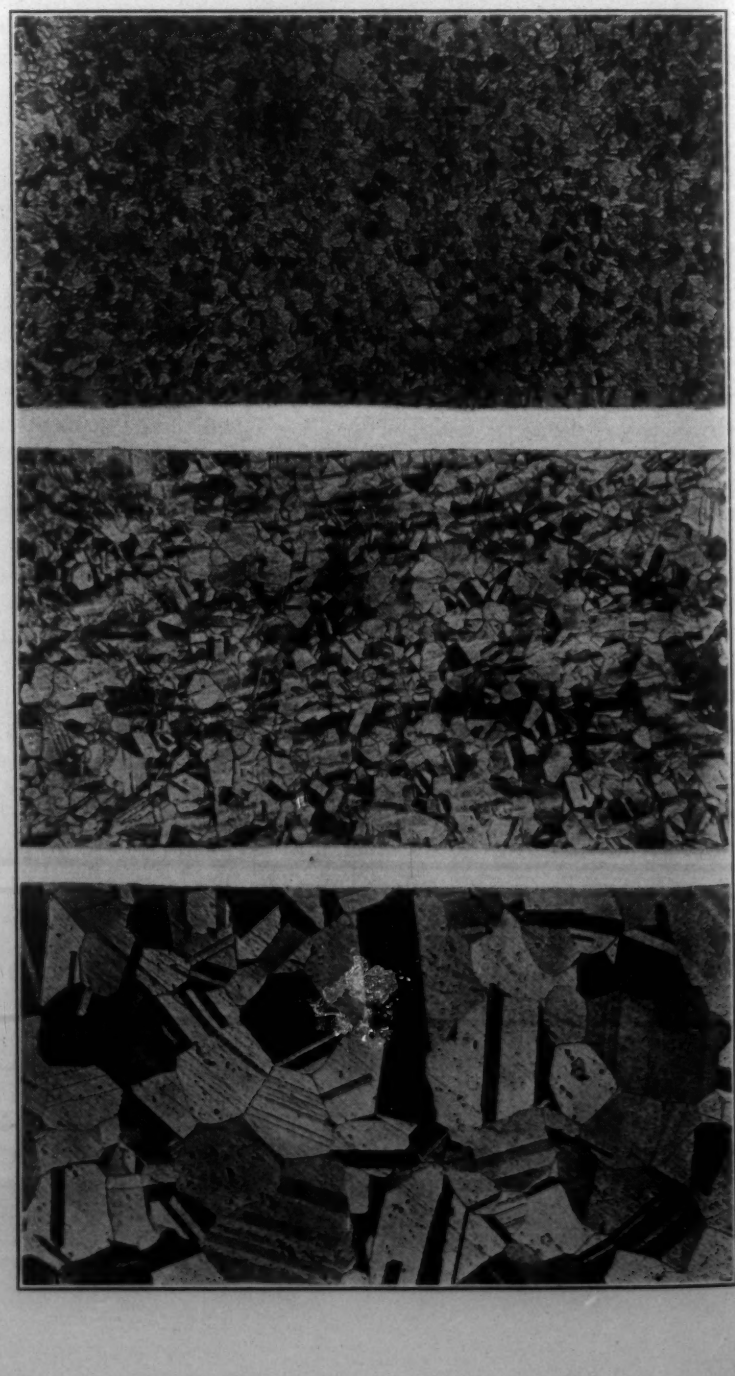
Use: Best suited for spinning operations.

Sample: Fig. 3.

Etching Reagent: Dilute Fe_2Cl_6.

Treatment: Rolled sheet was sheared and sample taken from the strained area. Annealed at about 650° C. in an electric furnace.

Remarks: Accelerated effect on grain growth by working or straining.



10% Nickel Brass: Cu 65%, Ni 10%, Zn 25%. Magnification 75 ×

Sample: Fig. 4.

Etching Reagent: NH_4OH 1:1 + 3% H_2O_2.

Treatment: Same as Fig. 1 but final anneal at 600° C. in electric furnace.

Remarks: Scleroscope hardness 22.

Use: Same as Fig. 1 but can be worked a bit more.

Sample: Fig. 5.

Etching Reagent: Same as above.

Treatment: Same as Fig. 2. Sample taken from center of bar and annealed at 675° C.

Remarks: Scleroscope hardness 19. Note parallel ridges and lack of uniformity in crystal size. Indicates working insufficient to destroy dendritic structure.

Use: Best suited for spinning operations.

Sample: Fig. 6.

Etching Reagent: Same as above.

Treatment: Same as Fig. 1, but annealed at 875° C.

Remarks: Scleroscope hardness 13. Grain growth has proceeded too far.

Use: Does not draw well and has no practical value.

Fig. 7—15% Leaded Nickel Brass: Cu 60%, Ni 15%, Zn 24.5%, Pb 0.5%. Magnification 75×, Etched in NH_4OH 1:1 + 3% H_2O_2

Treatment: Cast bar rolled and annealed once. Small black specks are metallic Pb which is insoluble in the alloy. It settles mostly along the crystal boundaries, thus causing the alloy to be easily machined. Dendritic structure has been partially destroyed and grain growth started. Use: for automatic screw-machines.

crystals presumably takes place and the strength of the metal is greatly reduced. The weakness of the metal at this point may be easily demonstrated by holding a hard rod of the alloy in the flame of a Bunsen burner and at the same time applying a bending strain with the fingers, not sufficient, however, to give the rod a permanent set. As the temperature of the metal rises and approaches its annealing point, the bar will suddenly snap like a rod of cold glass. This particular characteristic of the alloy is well known to those who work and anneal the metal, but as far as literature reveals, there has never been an investigation to ascertain what actually happens internally. This breakage is known as fire-cracking in the industry. If hard wire is curved from the rolls through which it passes, it can be annealed without injury to the product, but if the wire is allowed to come out straight and then forced into coils, it will crack through on both sides of the coil while it is in the muffle. A condition which brings about fire-cracking under very slight stress is the presence of lead. As low as 0.02% of this element under certain conditions will cause the metal to break under the slightest strain when being annealed. Therefore, nickel brass when spun must receive very light working and frequent anneals because of the unrelieved strains set up by the spinning operation.

When nickel brasses are cast, they have the dendritic or cored structure which is characteristic of cast metals and alloys. This structure can be destroyed by heavy working and annealing at high temperature, but commercially this is too expensive. Light working causes the crystals to grow rapidly on annealing but heavy working breaks up the crystals and they then grow in proportion to the temperature at which the metal is annealed.

Crystals of nickel brasses are of the equi-axed polygonal variety which characterizes all alpha-phase non-ferrous alloys. As in brass, twinning of the crystals occurs on working and annealing. The examination of nickel brasses metallographically presents a few problems over the examination of plain brasses. They are harder to polish than brass, especially if the nickel content is much over 15%. Use of a fine file, a fine grade of aloxite cloth, a wet flour-emery grinding, alundum, 65 F, or, less satisfactorily, tripoli, and finally, levigated alumina, are the steps in getting a good polish.

Like other copper alloys, nickel brasses require an oxidizing etching reagent. Alloys up to 15% nickel are easily etched with ammonium hydroxide and 3% hydrogen peroxide. Nickel brasses of 18% nickel or more may be etched by immersion or electrolytically. Electrolytic etching in a saturated solution of picric acid in ethyl alcohol works well on the 18% alloy but is not very satisfactory for higher nickel contents. The structure may be brought out with a 1% aqueous solution of chromium trioxide. Electrolytically etching in a 10% solution of citric acid works well, but it likewise cannot be relied upon to etch the higher nickel alloys. About the best electrolytic etch for nickel brasses is a 0.5% solution of potassium dichromate in water, keeping the specimen in motion. The solution should be discarded when it turns brown. For alloys above 25% nickel a solution of 3 parts nitric acid, 3 parts glacial acetic acid and 4 parts water works well, the only objection being that little contrast is produced. Perhaps the best all-around reagent is a 30° Baumé solution of ferric chloride in water, best diluted 2 parts of the solution to 1 part of water for photomicrography, but for ordinary examination it is all right concentrated.

The increasing use of alloy steels would seem upon first consideration to be a detriment to the nickel brass industry. Instead, it has opened up new fields and the production of the older alloy is increasing steadily. The two go hand-in-hand, for in many instances an article is not required to be made entirely of steel. The part which needs a hard metal is formed from the steel (the blade of a table knife, for instance), and the remainder made of nickel brass. One has only to look about to see the results produced by this alloy; camera parts, auto trimming, mesh bags, hookless fasteners, tableware, ornaments, radio equipment, electrical fixtures, bead-chains and so on down the whole long list of familiar articles. The alloy is so common that we look upon it without thought as to what it actually is.

A New Solder for Electrical Apparatus

By Dr. James Silberstein*

The eutectic arrest at 182.5° C. in the equilibrium diagram of tin and lead (see Fig. 1) stretches from practically pure tin to alloys containing about 85% lead. This means that a joint soldered with any of the lead-tin solders used in common soldering practice will fail if heated to or above 182.5° C.

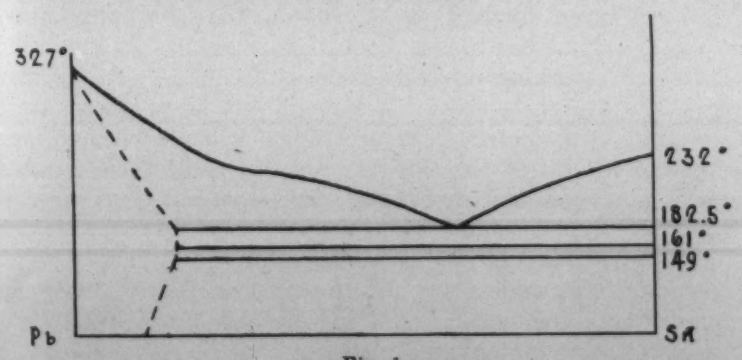


Fig. 1

A solder withstanding higher temperatures but yet not requiring such high heat for its application that adjacent insulation will be burnt is very desirable for certain electrical apparatus. Attempts have therefore been made—especially during the World War when there was a shortage of tin—to use other alloys as solders. These failed, however, either because of unsatisfactory physical properties or inability to be applied with the non-corrosive fluxes employed in the soldering of electrical apparatus.

* Chicago, Ill.

Properties Required for Soldering.—Two requirements may be considered necessary for soldering: Perfect cleanliness of the surfaces to be soldered and ability of the solder to alloy with the metals to be soldered. The necessity of the first requirement can be taken for granted without any comment. The second requirement also appears to be necessary, but on second thought the question arises whether alloyability in its ordinary sense really must be required for causing the solder to adhere. From a strictly theoretical point of view all metals must be considered miscible and, therefore, alloyable at least to a small degree. This follows from the fact that miscibility is a thermodynamical necessity which always occurs, if in some cases only to an infinitesimal extent. An infinitesimal miscibility may, however, be all that is necessary for causing a solder to adhere, provided, of course, that the surfaces to be soldered, are chemically clean. If this is true, the second requirement may just as well be dropped and only the first requirement remains.

It can be proven experimentally that alloyability is not a necessary requirement for soldering. Lead does not alloy with aluminum, and yet, it is possible to bring about a very tenacious adherence between lead and aluminum if only the aluminum is chemically clean. Since aluminum readily oxidizes and practically always is covered with a film of aluminum oxide a way must be found of removing this film and simultaneously preventing access of air so as to avoid re-oxidation of the aluminum.

This can be done by using lead chloride both as flux and solder. Lead chloride reacts with aluminum according to the formula

$$2\ Al + 3\ PbCl_2 = 2\ AlCl_3 + 3\ Pb$$

with formation of lead. The experiment is easily carried out by placing some lead chloride on a piece of sheet aluminum and holding the sheet in the flame of a Bunsen burner until formation of fumes of aluminum chloride when the sheet should be removed, since otherwise the reaction becomes too violent. On cooling and rinsing with water to remove excess salt it will be found that the precipitated lead adheres so tenaciously to the aluminum that the strength of the bond must be considered practically as great as the cohesive strength of lead.

Experiments and Tests.—It was evident at the start of this investigation that only lead or certain lead basic alloys would possibily satisfy the requirements for a solder for electrical apparatus mentioned in the beginning of this article. The use of unalloyed lead is not a practical proposition since the rosin of the flux has a tendency to carbonize at the temperatures required for soldering, thus preventing the lead from adhering to the surfaces to be soldered. Another disadvantage is the ease with which lead oxidizes at and above its melting temperature.

The melting point of lead—and consequently also the soldering temperature—can be decreased by alloying. Because of the properties required for a solder for electrical apparatus there are only two metals—silver and tin—which can be considered for this purpose. Tin cannot be added in any considerable percentage since otherwise the joint will break down at 182.5° C., and an alloy containing 3.5% tin and 96.5% lead was therefore tested. Silver forms a eutectic alloy with lead at 2.25% silver, the eutectic arrest occurring at 303° C.[1] Silver increases the solubility of copper in lead and, since copper has a favorable influence on the physical properties of the alloy, several ternary silver-copper-lead alloys were tried as solders. The one which proved to be the best contained 2.50% silver, 0.25% copper and 97.25% lead. The question may be asked why the ternary eutectic alloy, containing 2.04% silver, 0.50% copper and 97.46% lead and melting at 302.5° C.[2] was not found suitable as solder. The answer is that a metal or an alloy with a sharp melting point is not as well adapted for soldering purposes as an alloy with a melting range. This has been proven by practical experience as well as by tests which will be described later.

The relation between temperature and cooling rate for the 2.50% silver, 0.25% copper and 97.25% lead alloy is reproduced in Fig. 2, where two arrests are shown, the eutectic one—which with the instrument used occurred at 304.7° C. instead of at 302.5° C.—and one upper arrest at 349.5° C.

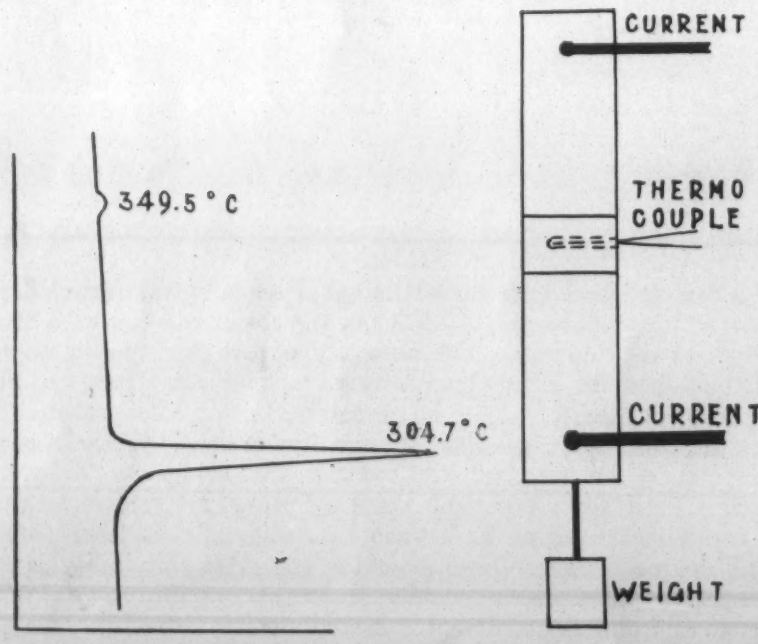


Fig. 2

Fig. 3

Since joints often are subjected to stresses the most practical method of determining the temperature of failure is to heat a soldered joint, held under load, until failure occurs. Two copper strips $1/8'' \times 1'' \times 10''$ were soldered together, overlapped, the soldered area being $1'' \times 1''$ as shown in Fig. 3. A hole, $1/16''$ diameter and $3/4''$ deep, was drilled in the upper strip and a thermocouple placed in the hole. A weight of 50 lbs. was attached to the lower strip and electric current passed through the strips until the joint failed. Several tests were made using this method.

[1] *Zeitschrift anorganische und allgemeine Chemie*, Vol. 53 (1907), page 200.
[2] *Metallurgie*, Vol. 4 (1907), page 293.

The solders tested and the temperatures of failure were the following:

(1) 42% tin, 58% lead alloy failed between 175 and 179° C.
(2) Pure tin failed between 210 and 214° C.
(3) 3.5% tin, 96.5% lead failed between 230 and 239° C.
(4) 2.5% silver, 0.25% copper, 97.25% lead failed between 296 and 301° C.
(5) Pure lead failed between 314 and 317° C.

The above tests show that, eliminating lead, which is undesirable from a practical standpoint, the silver-copper-lead alloy stands the highest temperature under stress. The temperature of failure of the 3.50% tin, 96.50% lead alloy may appear low, since this alloy according to the equilibrium diagram should begin to melt at about 280° C. Alloys as cast are, however, as a rule not in equilibrium and the tin lead alloys are no exception to this rule.

Another test which shows the relative value of solders in withstanding high temperature under load and electric current carrying conditions was the following: Copper strips, $1/16'' \times 1'' \times 5''$, were soldered with the following three kinds of solders: 42% tin, 58% lead alloy; pure tin; and the 2.50% silver, 0.25% copper, 97.25% lead alloy. Four lap joints were made with each kind of solder, the soldered section being $1'' \times 1''$ in all cases (see Fig. 4). Electric current was passed through the strips, which were under tension, until the joints failed. When one joint had failed, contact was made at this place by brass clamps, and the test continued.

Considering the fact that the 42% tin, 50% lead has the lowest melting point, failure would be expected first on all joints soldered with this alloy. However, one joint, soldered with the 42/58 alloy failed first, one, soldered with tin failed next, then one soldered with the 42/58 alloy, then a tin-soldered one and so on. This test was first conducted with a series of bare strips, and then repeated with a series of insulated ones. In both cases the result was the same, namely that the joints soldered with the 42/58 alloy and with pure tin failed at the same current, and no marked superiority of the tin-soldered joint over the joints soldered with 42/58 alloy could be found.

The joint soldered with the silver-copper-lead alloy failed at much higher current. The failure of the tin-soldered joint and the joints soldered with the 42/58 alloy at the same current is due to the following fact: Tin, as well as other pure metals and eutectic alloys, has a sharp melting point, above which it is perfectly liquid and below which it is perfectly solid. Such metals have a tendency to run through joints when used as solders, while alloys with a melting range in which the metal is partly liquid and partly solid do not have this disadvantage, and the latter, therefore, give better joints. Since the 42/58 alloy has a melting range and pure tin only has a melting point, joints soldered with

Fig. 4

the 42/58 alloy must be better and their electrical resistance lower than joint soldered with tin. This, in turn, means, that the former joints are heated to a lower temperature than the latter by a given current, or in other words, the apparent advantage of the higher melting point of tin is off-set by its disadvantageous working properties.

Several other tests were conducted, but since these are of interest solely to electrical engineers they will not be mentioned here. The results of these tests were favorable for the silver-copper-lead alloy solder and it was, therefore, put in service.

Practical Application.—The use of the silver-copper-lead alloy solder is to be recommended for electrical apparatus where the common soft solders are apt to fail on account of too high temperatures being encountered in service. Service results of railway and mine motors where the new solder has replaced the old ones have been very satisfactory and the soldering trouble, previously experienced, has been eliminated. The first place where the new solder was applied on a practical scale, was in the motors of the electric locomotives of the Virginian Railroad, which at the time of this development (in 1927) were the largest and most powerful in the world. Later the solder was used in other railway and mine motors, where trouble with the old solders had been encountered. The results have in all cases been very satisfactory.

Extended Abstracts

Selected articles that appear to be of outstanding importance or interest will be abstracted in this section at greater length than Abstracts of Current Metallurgical Literature. The important points will be given fully enough to obviate for the purposes of most readers, the necessity of going to the original article, but in a distinctly condensed form. These abstracts are not critical.

A New Dead-Weight Testing Machine of 100,000 Lb. Capacity[1]

By L. B. Tuckerman, H. L. Whittemore[2] & S. L. Petrenko

The use of dead weights in the calibration of testing machines for applying forces to specimens of engineering materials involves serious disadvantages and is practically out of the question for horizontal testing machines. Accordingly, experiments were undertaken with apparatus which could be calibrated under accurately known forces and then used to measure the forces applied by testing machines. The requirements (1) that this calibrating apparatus should be portable, allowing it to be transported to the testing machine, and (2) that it should be accurate made the development difficult and slow. A solution was finally found in the Whittemore-Petrenko proving ring.

Briefly, this instrument is a ring of heat-treated alloy steel to which forces may be applied along a diameter. The change in the diameter caused by the force is measured by a screw micrometer. A comparison of this device with other calibrating devices seems to show that the readings, on the average, are more accurate. It is also sufficiently rugged in construction to withstand field service.

After the development of the proving ring, it became necessary to provide means for applying accurately known forces to these rings in order to determine their calibration constants. A dead-weight machine was, therefore, designed in cooperation with A. H. Emery of Stamford, Connecticut, and built by Mr. Emery.

This machine was installed in November, 1927, and can be used to apply either tensile or compressive forces to elastic or other portable calibrating devices by increments of 10,000 lb. after an initial load of 2000 lb. has been applied. The maximum force (or load) is 102,000 lb.

This dead-weight machine is about 30 feet high and about 12 feet wide. The weights are on the first floor of the middle wing of the Industrial Building, the forces are applied to the calibrating device on the second floor, and a jack for lifting the weights is on the third floor. The machine is shown in the photographs, Figs. 1, 2, 3 and 4. The frame of the machine consists of two reinforced-concrete columns A-A, Figs. 1 and 2, extending from the concrete foundation at the base to the third floor where two steel I-beams B-B, Fig. 3, are placed across the tops of the columns. On these steel beams rests the hydraulic jack C, Fig. 3, which is operated by an electrically driven pump, which is not shown. The control valves are in the case D, Fig. 2, on the second floor.

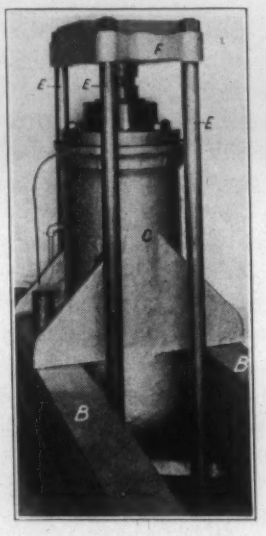


Fig. 3

The apparatus for applying forces to the device to be calibrated consists of two frames. The upper frame, Figs. 2, 3 and 4, consists of three yokes F connected by four rods E. The lower ends H-H of two of these rods move in guide in the second floor. The top yoke F, Fig. 3, rests on a steel ball on the ram of the jack to insure axial loading. The lower frame, Figs. 2 and 4, consists of two yokes G connected by two rods L. These rods move vertically in guides I-I, Fig. 2, in the middle yoke of the upper frame. The upper yoke of the lower frame may be adjusted vertically on threaded rods L by rotating the nuts in the yoke by means of the electric motor and gearing shown in Figs. 2 and 4. This adjustment makes it possible to load proving rings or other calibrating devices either in tension or compression. The maximum distance between the loading yokes is about 6 ft. 6 in. To the lower yoke of the frame is suspended the loading bar J, Fig. 1, for lifting the weights K-1, K-2, etc., Fig. 1.

To apply forces to the calibrating device, the ram of the jack is raised, carrying the upper frame with it. The motion of the jack is transmitted to the lower frame through the proving ring or other calibrating device in the machine.

When the loading bar is raised about $^3/_4$ inch, a head on the lower end of this bar engages a bevel seat in the axis of the top weight K-1. On raising it further, a head on the top weight similar to the one on the loading bar engages the seat in the next

[1] Slightly condensed. The complete account may be found in the *Bureau of Standards Journal of Research*, Vol. 4, Feb. 1930, pages 261–264.

[2] Chief, Engineering Mechanics Section, the National Bureau of Standards.

Fig. 1

Fig. 2

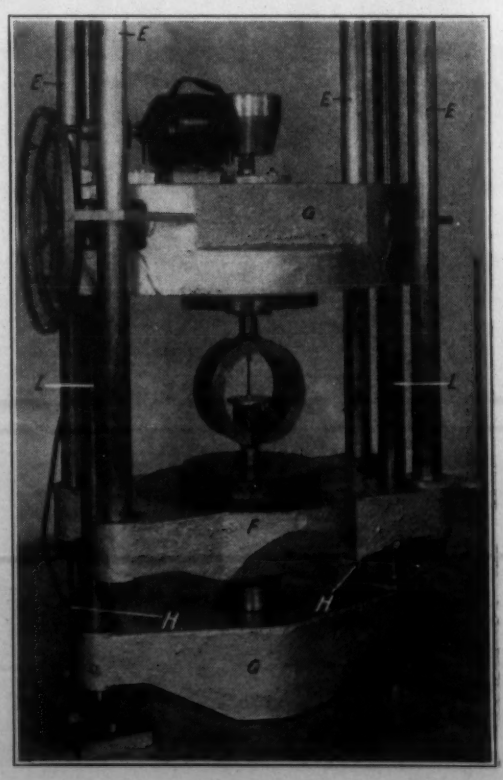


Fig. 4

weight K-2. On continuing to raise the loading bar, the other weights are suspended from it in succession until, when it is raised about 10 inches, all of the weights are suspended.

The weights are removed by lowering the jack. This action allows the bottom weight to come to rest on a bevel seat built into the foundation and each of the other weights in succession to rest on a similar seat on the weight below.

In Fig. 2 a proving ring having a capacity of 100,000 lb. is shown in the dead-weight machine ready for the application of tensile forces. In Fig. 4 the same ring is shown ready for the application of compressive forces.

The deformation of the proving ring is measured by reading the micrometer under the desired load.

Sleeves are provided in the guides I for the lower frame. These sleeves can be rotated by hand to eliminate frictional forces on the rods L.

The weights are of cast iron and have a diameter of about 84 inches and a thickness of about 7.5 inches. Each one was carefully balanced. The center of gravity was in no case more than 0.018 inch from the geometrical center, the average being about 0.008 inch, and the weight was adjusted to 10,000 lb. before the machine was assembled. The maximum error in the weight of the lower frame (2000 lb.) or of the cast-iron weights (10,000 lb.) was about 0.1 lb.

Large cast-iron weights have been used in the railway test car of the Bureau of Standards for calibrating track scales. These weights are transferred by a crane from the car to the scale and then reloaded into the car after the calibration. In service they are thus exposed to the weather.

Verification of these weights after they had been used for 2 years showed differences from the original weight, about 100,000 lb., of as much as 5 lb. which was sometimes a loss and sometimes a gain.

It is believed that no greater change in the weights for the dead-weight machine is to be expected.

Great care was taken in assembling the machine to secure axial alignment of all the parts. After all the weights were placed in position on the bevel seat on the foundation, measurements showed that the center of the top weight was only about 0.06 inch from the vertical line of the machine and that its upper surface made an angle of about 28 minutes of arc with the horizontal.

Measurements on each weight after it was placed in position showed that its axis was nearer the center line and its upper surface more nearly horizontal than in the case of the top weight.

After the machine was assembled, the jack which had been placed vertically about the center of the top weight was moved one-half the horizontal distance between the center of the bottom weight and the center of the top weight, or 0.03 inch, so that the maximum distance between the axis of any weight and the axis of the machine is now 0.03 inch.

To establish and maintain the vertical alignment of the machine a "reference plate" was built into the floor just below the jack. From a carefully located "center" in this plate a plumb line was suspended to fix the axis of the machine. This line can be replaced at any time to check the alignment of the machine, and adjustments, if necessary, can then be made.

The dead-weight machine is used not only for determining the calibration constants of proving rings and other devices for the Bureau, but it is used also to calibrate similar devices for the public for which a nominal fee is charged.

The problem of calibrating proving rings having capacities above 100,000 lb. has been given serious consideration. It does not appear practicable to build larger dead-weight machines; therefore, other methods will be studied in an endeavor to obtain satisfactory calibrations of proving rings which can be used for forces of 1,000,000 lb. or more. This work is expensive and must necessarily await the provision of funds and personnel.

The Bureau has in the past received many requests for calibrating testing machines in different parts of the country, but this calibration cannot be undertaken without adequate provision for the apparatus, trained personnel and traveling expenses.

Rapid Expansion in Consumption of Chromium

Rapid expansion in the consumption of chromium, begun in 1922, has continued in recent years, and present indications are for further increase in consumption, says Lewis A. Smith, in a review of the situation made public by the United States Bureau of Mines, Department of Commerce. The most noteworthy developments include the extensive adoption of chromium plating, especially for automobile parts; the increased utilization of rustless iron and steel and nickel-chromium steel; and the further substitution of chromite refractories for magnesite refractories, due to a favorable price differential. The tanning industry appears to be turning more and more toward chromium reagents. The demand for chromium pigments seems to have been maintained.

Shipments of chromite from mines in the United States in 1928 were more than three times those in 1927, but were still relatively insignificant. Favorable development of the large chromite deposits of Southern Rhodesia continued in spite of the lack of adequate transportation, and a record output of 195,918 long tons was made in 1928. The rapid development of the Transvaal chromite area was a leading event in the Union of South Africa in 1928. Further discoveries of chromite have been made in Canada and Indo-China, the latter being the more important at the present state of development, although of lower grade. The promising Baluchistan deposits of British India continued to develop favorably, and Soviet interests were actively engaged in an attempt to rehabilitate the Ural chromite industry. The deposits of the Shetland Islands, Scotland, are still working, and the concentrated product appears to be suitable for pigment manufacture. In Turkey the United Swedish Steel Works Co. has acquired concessions in the Eskishehir, Kosfindkik and Ecrenos areas and is doing development work; the Brusa deposits have been assigned to a Turkish company on a 60-year basis; and a British firm controls one of the large deposits of Smyrna. The Turkish production in 1928 was nearly twice that in 1927.

The development of successful electric smelting methods for making stainless steels direct from chromite and iron ore may lead to a solution of the metallurgical difficulties in attempting to handle the chromiferous nickel iron ore deposits of the lateritic type. The known reserves in these deposits are so large that they indicate a source upon which a stable and lasting industry might be built.

In the United States 368 long tons of chromite were mined during 1928, and 660 tons were shipped, compared with 50 tons mined and 201 tons shipped in 1927. The United States imported 216,592 long tons of chromite during 1928, a decrease of 5768 tons from the 222,360 tons imported in 1927. In 1927 the United States imported 55% of the total world production, but in 1928 only about 49% of the probable world output of about 442,000 tons. Southern Rhodesia, exporting through Portuguese East Africa, again furnished more than half of the total United States imports; the quantity imported from this source in 1928 was 112,073 long tons, or nearly 17,000 tons less than in 1927. Cuba, British India, Greece, Union of South Africa and New Caledonia each furnished more than 15,000 tons, and smaller amounts were obtained from Brazil, Cyprus, Turkey and the Netherlands. Cuban imports nearly doubled as a result mainly of operations by the Bethlehem Steel Corporation in Cuba; these ores are suitable for the manufacture of refractory materials. The New Caledonia ore is best fitted for chemicals and pigments because of its comparative purity.

The estimated world production of chromite in 1928 was about 449,000 metric tons, an increase of 41,000 tons over 1927. The production in Rhodesia increased slightly to 199,060 metric tons in 1928 and was about 44% of the estimated world output. The exports from New Caledonia in 1928 were 56,698 metric tons, compared with 42,885 tons in 1927. Practically all Cuban production is shipped to the United States; imports from Cuba into the United States amounted to 34,248 metric tons in 1928, compared with 17,256 tons in 1927. Production in Greece in 1928 is reported as 20,953 metric tons, but imports into the United States from Greece, which usually account for a large part of the actual Grecian output, decreased 24% in 1928. The Union of South Africa produced 31,756 metric tons in 1928. Brazil, India, Japan, Russia, Turkey, the United States and Yugoslavia also contributed to the world total.

From a world-wide view of the chromite situation, considering past production, consumption, prices, potential production and producing capacity, the deposits of Rhodesia, India, Union of South Africa, Turkey, Greece and New Caledonia appear capable of supplying the world demand with ease for many years.

The "Microchilled" Surface of Some Cast Irons and Its Relation to Blistering in Enameling*

By A. I. Krynitsky[1] and W. N. Harrison[1]

Condensed by Emerson P. Poste

The investigation of variations in the tendency of vitreous enamel to blister when applied to different cast irons was taken up by the Bureau of Standards at the suggestion of the Enamel Division of the American Ceramic Society.

The trouble is more pronounced with enamels applied by the "wet" process and the investigation is therefore confined to that type of enameling. The finely ground water suspension of enamel is sprayed onto the casting and dried. The coated piece is heated to maturity of the enamel. In some cases a special "ground" coat is processed first, followed by a similar application of the "cover" coat, while in others the desired "finish" enamel is applied directly on the casting.

Blisters are caused by gases becoming entrapped in the finished enamel. Variations in processing and in the physical properties of enamel during firing may be important factors in regard to blistering. If the combination is such as to allow evolved gases to escape through the enamel while it is relatively fluid, no final blisters are produced.

It is claimed by some that southern pig irons are less liable than northern irons to produce blistering. The former are held to contain more phosphorus as a rule. High manganese and high sulphur are thought to give trouble. Various ideas as to the effect of silicon and different forms of carbon have been advanced. Annealing is quite generally believed to improve irons tending to produce blistering. Proper cleaning of iron before enameling is certainly necessary for satisfactory results. In approaching the problem the Bureau carefully considered these several opinions.

Enameling Tests.—Preliminary experimental work with two irons, the one having a "very slight tendency to blister," the other "strongly blistering," failed to suggest any specific relation between the apparent nature of iron and blistering as indicated by enameling under uniform conditions. Firing series of samples over a range of time—temperature relations produced relatively uniform results with the slightly blistering iron but in the case of the strongly blistering iron it developed that blistering was less pronounced under certain firing conditions than under others.

New lots of slightly blistering and strongly blistering iron were used in a second comparison, each lot of samples being fired over a wide time-temperature range. Previous conclusions were checked.

Removal of Surface Layer.—Machining off the surface layer of iron prior to enameling eliminated blistering as shown in Fig. 1. Additional machining tests indicated the offending layer to be very thin. Deep pickling or very severe sand-blasting produced like beneficial effects.

These experiments proved that blistering of the type under investigation is not due to gas absorbed in the body of the casting or differences in composition or structure of the body of the casting but that "the nature of a very thin surface layer was responsible for blistering."

On the supposition that a "softer" iron would possess a surface layer more thoroughly removable by ordinary sand-blasting, additions of 1/2 and 2% nickel and 1% aluminum to the strongly blistering iron at the ladle were tried but with no positive results. The addition of silicon in the furnace, however, improved the iron as to enameling quality as shown in Fig. 2. The amount of silicon added is thought to produce lower combined carbon in the surface layer but not in the body of the casting.

It was proven that burnt in molding sand was not a direct cause of blistering though it would retard the removal of the outside layer of metal during sand-blasting.

Nature of Surface Layer.—Comparative compositions of surface layer and interior of badly blistering iron are shown in Table I. The increase in combined carbon at the surface is possibly significant as obviously accompanying the presence of a hard surface layer. "There seems, therefore, to be a 'microchilled' surface layer (micro here refers to the thickness of the chilled layer) which is apparently not necessarily controlled by the propensity of the iron to chill in the ordinary sense of giving a visibly thick layer of white iron on rapid cooling, and which may be different in its nature from an ordinary chilled layer."

Microscopic examination of the microchilled layer indicated much less combined carbon in the more mildly blistering iron.

The higher nitrogen content of the surface layer (Table I) and the especially high amount in the surface of the badly blistering iron did not escape attention. Nitrided coatings containing as much as 1% nitrogen were produced on samples of the least blistering iron. Enamel applied to these test pieces did not blister.

* *Preprint 30–9, American Foundrymen's Association*, May 1930, 38 pages; *Bureau of Standards, Journal of Research*, Vol. 4, June 1930, pages 757–807; *Journal, American Ceramic Society*, Vol. 13, Jan. 1930, pages 16–61.

[1] Bureau of Standards, Washington, D. C.

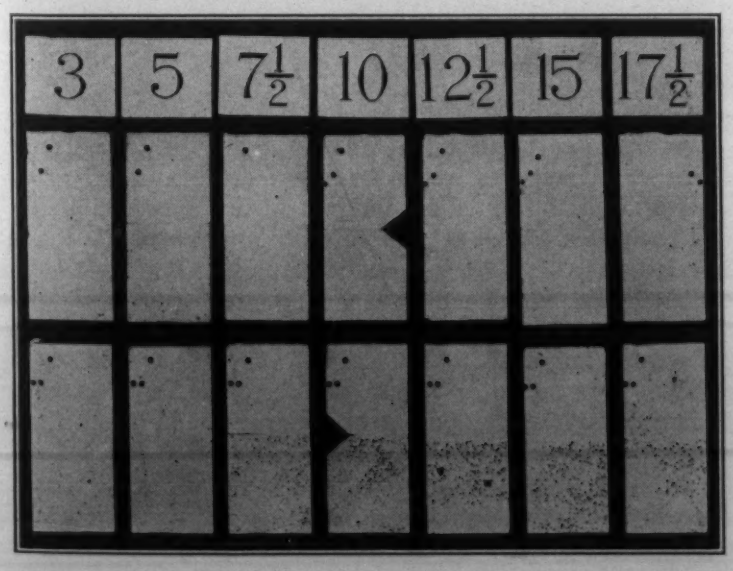


Fig. 1—Surfaces (End of the Plates Bearing the Identification Holes) Were Machined Off before Enameling. The Other Half Was the Cast Surface. Top Row Iron R_2 (Weakly Blistering) and Bottom Row Iron L_2 (Strongly Blistering). Numbers Indicate Minutes of Firing Ground Coat at 875° C. (1605° F.). Cover Coats All Fired 8 Minutes at 800° C. (1470° F.)

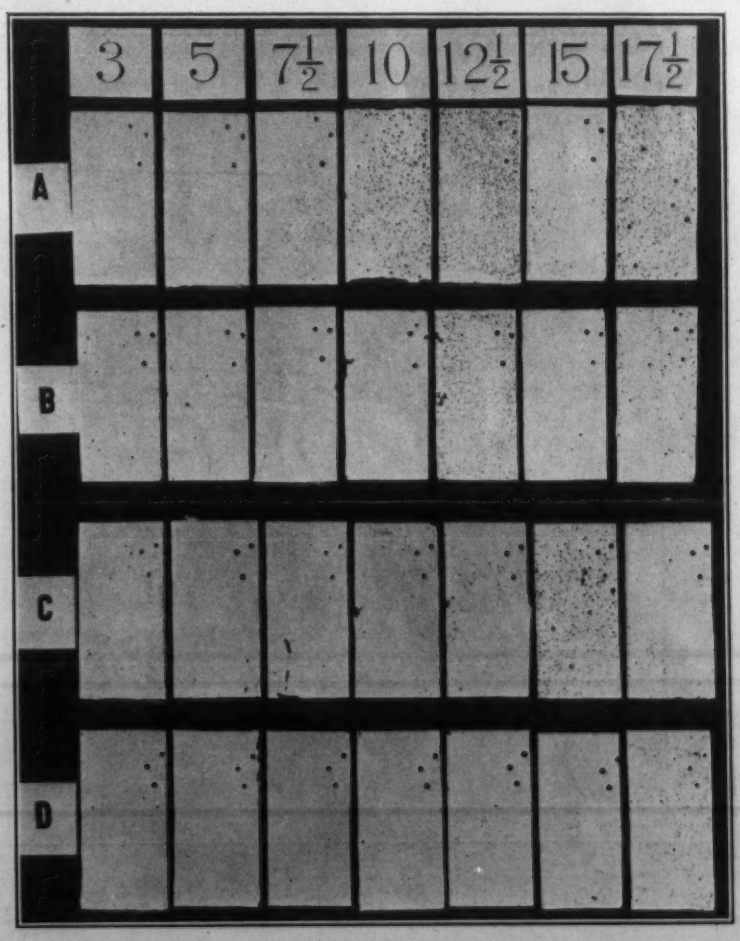


Fig. 2—Effect of Silicon Additions on Blistering Tendency

A—2.32% Si, B—2.51% Si, C—2.65% Si, and D—2.92% Si. Average of two determinations. Numbers indicate minutes of firing ground coat at 875° C. (1605° F.); cover coats all fired 8 minutes at 800° C. (1470° F.).

Table I—Chemical Composition of Surface Layer and Interior of Cast Plates of Irons L_2 and R_2

Elements	L_2 Heat No. 2–55 (Badly Blistering) Outside Layer 0.003 In. Thick	L_2 Heat No. 2–55 (Badly Blistering) Comparison Layer (0.01 In. Thick) Several Hundredths Inch beneath the Surface	R_2 Heat No. 3–56 (Weakly Blistering) Outside Layer 0.003 In. Thick	R_2 Heat No. 3–56 (Weakly Blistering) Comparison Layer (0.01 In. Thick) Several Hundredths Inch beneath the Surface
Total C	2.71	3.54	2.84	3.31
Combined C	0.45	0.34	0.42	0.27
Graphitic C	2.26	3.20	2.42	3.04
Manganese	0.61	0.73	0.45	0.61
Phosphorus	0.435	0.500	0.605	0.835
Sulphur	0.044	0.037	0.031	0.022
Silicon	2.42	2.63	2.33	2.46
Nitrogen	0.0033	less than 0.0005	0.0015	less than 0.0005
Total	6.22	7.44	6.26	7.24
Iron by difference	93.78	92.56	93.74	92.76

Analysis of certain specimens of the two types of iron for Cu, Ti, Cr, V, Al, O and H gave data which, in view of the facts at hand, suggested only a possible relation between Cr and blistering. The known effect of Cr on chill in cast iron is in line with the possibility of its having a particular relation to the microchill. The addition of 0.03% Cr to a weakly blistering iron increased blistering but larger additions (0.05 and 0.10%) showed no effect.

Analytical data did not point to either oxygen or hydrogen in the metal as gases which could cause blistering.

Sulphur determinations on samples of thin surface layers from blistering iron before and after heating equivalent to enameling indicated no change in the amount of sulphur; the blister forming gas was, therefore, not SO_2.

Composition of Evolved Gas.—Indirect methods having failed to indicate the nature of the blister forming gas, an elaborate series of tests was made clearly showing the gas to be a mixture of CO and CO_2, later referred to as CO_2. Further work involving determinations of CO_2 evolved during firing of ground and cover coats showed no definite variation in the total amount of gas from blistering and nonblistering iron.

Rate of Gas Evolution.—If CO_2 is the cause of blistering, but essentially like total amounts are evolved from blistering and non-blistering irons, the relative rate of gas evolution during different stages of the fusion of the enamel was indicated to be worthy of attention.

A careful study of the amount of gas evolved by various types of iron when fired for different lengths of time gave the data plotted in Fig. 3. Up to a firing time of from 8–10 minutes the rate of CO_2 evolution is about the same in all cases. Beyond that time of heating, the weakly blistering irons evolved practically no more gas while the unmachined badly blistering iron (1–55) continued to give off gas at a rapid rate. The machined sample of this iron, however, ceased to give off appreciable amounts of gas after 10 minutes' heating. A machined sample of a weakly blistering iron (2–56) behaved in essentially the same manner as the unmachined iron. These data indicated a relation between rate of gas evolution and condition of enamel. Gases evolved early in the normal firing period, or during ground coat firing, rather than the later stages of cover coat firing, are not entrapped in the enamel, but irons which continue to evolve gas over the entire firing range cause the latter portions of the gas to become entrapped as blisters.

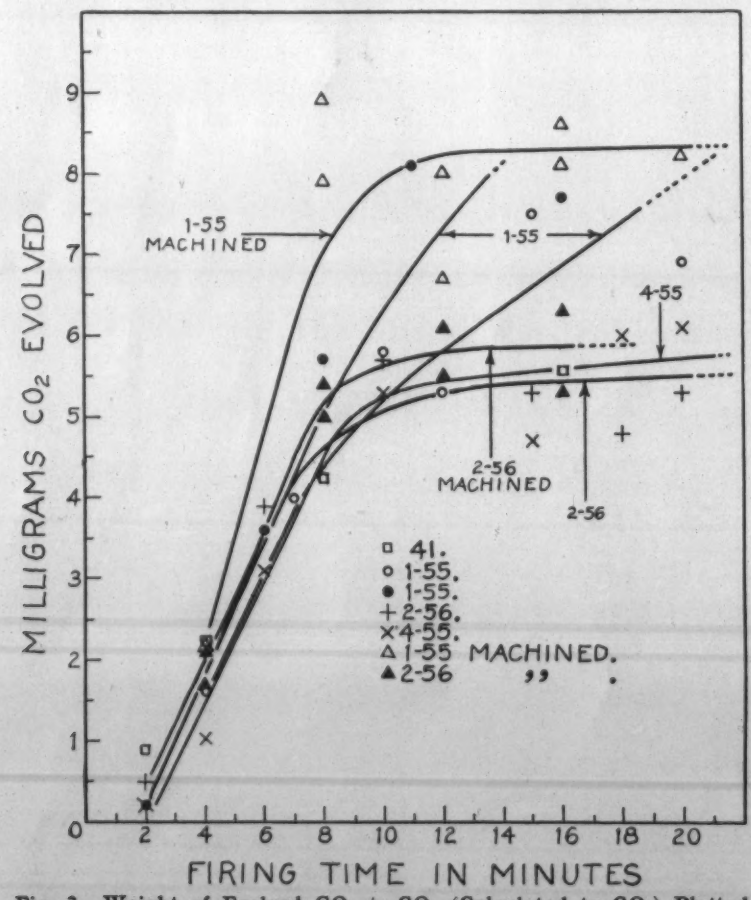


Fig. 3—Weight of Evolved CO + CO_2 (Calculated to CO_2) Plotted against Firing Periods

All specimens completely coated with ground coat and fired at 875° C. (1605° F.) in CO_2-free atmosphere. Each point represents one specimen and the corresponding analytical determination. L_2-1-55 is a strongly blistering type of iron, while all of the others (including L_2-1-55 machined) are weakly blistering ones.

The evolution of CO_2 is held to result from oxidation of carbon in the metal, the rate of which is apparently the determining factor.

Supporting this theory, gas evolution data are in line with the behavior of various irons on enameling. Mildly blistering irons have wide firing ranges while badly blistering irons have very narrow limits of firing. The amount of blistering is controlled by the rate of gas evolution at that part of the firing process in which the enamel is sufficiently fused to entrap the gas. In the case of two-coat ware, gas evolution in the better irons is completed during the firing of the ground coat and the later firing of the cover coat causes no harmful gas evolution.

Carbon Reactions in Surface Layer during Enameling.—The belief that blistering is due to CO and CO_2 resulting from oxidation of carbon in the microchilled surface layer led to a study of the carbon in this surface. It is held that the reactivity of different varieties of carbon varies with the surface-volume relation of the particles and with the mode of formation. There are also relations between CO and CO_2 formed and rate of decomposition of cementite by decarburization and by catalytic action. It is probable that massive graphite is not responsible for blistering. Careful work with the microscope has shown that there may or may not be blisters at graphite flakes appearing at the very surface of the metal. It is assumed that there may be particles of graphite too fine for resolution under the microscope. References to the literature substantiate this idea. Probably the more rapid evolution of gas during the first minutes of heating is in all cases caused by the oxidation of these submicroscopic particles of graphite in and beneath the surface layer. This reaction is taken to be completed in the early stages of firing and not responsible for subsequent evolution of gas causing blistering.

Chilled iron has been said by some to blister and by others not to blister. It is thought that the difference in opinion might come from variations in conditions tending to promote or retard graphitization, such as massiveness of the cementite formation, the presence or absence of elements which tend to stabilize cementite, superheating of the metal, and the like.

Experimental enameling of white iron produced bad blistering over the whole range of firing temperatures. The same held for machined samples. Annealing for 5 hours at 950° C. or 1740° F., followed by furnace cooling, greatly reduced blistering. This long heating probably produced some decarburizing. Shorter heating for 45 minutes followed by furnace cooling also greatly diminished blistering. The annealing produced well agglomerated "temper" carbon, practically massive graphite. The short heating of enameling caused decomposition of cementite but very little agglomeration. Malleable iron in which most of the temper carbon was well agglomerated, did not blister when enamel was fired from 7.5–10 minutes, but blistered badly at 12.5–15 minutes. Well agglomerated temper carbon is taken to be nearly as non-reactive as massive graphite. The great activity of colloidally dispersed temper carbon, just as it forms and before it agglomerates is in sharp distinction to the lower activity of the agglomerated material.

Sample pieces were cast from weakly blistering iron using a wide range of moisture content of molding sand. No difference in blistering was produced.

To study the effect of definite chilling the strongly blistering and weakly blistering irons were cast into blocks 2 inches thick against (a) green sand, (b) chill plate covered by $^1/_4$" green sand and (c) chill plate. Two $^3/_{16}$" enameling specimens were cut from each; the first, the layer against the mold (a, b and c), the second, the next $^3/_{16}$" slice. The first slice of the weakly blistering iron cast against green sand enameled quite well while the corresponding sample of badly blistering iron blistered.

In both cases the second layers enameled well. Both of the outside pieces cast against the covered chill plate blistered badly while the outside pieces showed equal improvement. When cast against the chill plate the strongly blistering iron blistered as with severe chilling. However, the weakly blistering iron blistered less on the strongly chilled surface than it had on the corresponding weakly chilled surface. In the interior ($^3/_{16}$" from the outside) the severely chilled weakly blistering iron behaved on enameling the same as the surface when less severely chilled.

The decomposition of cementite producing temper carbon or graphite which occurs in a chilled or microchilled layer, during enameling doubtless depends on (a) the original content of combined carbon, (b) the composition of the iron as to elements that promote or hinder graphitization and (c) the time and temperature of enameling. If all of these conditions are such that there is no breakdown of combined carbon during enameling the iron is non-blistering. This would apply to stable white or gray iron. But if colloidally dispersed temper carbon is produced in the chilled layer the iron will blister. Higher temperatures and longer firing periods accentuate the tendency.

Thus the blistering for which the combined carbon is responsible may be traced to the breakdown of combined carbon to temper carbon at a stage during enameling at which oxidation can occur and at which the enamel is in such a physical condition as to retain the carbon monoxide and dioxide formed. This offending breakdown may be prevented by the nature of the chilled layer itself; by removing the surface layer, avoiding conditions which will produce this layer, decarburizing the surface or accomplishing the breakdown before enameling.

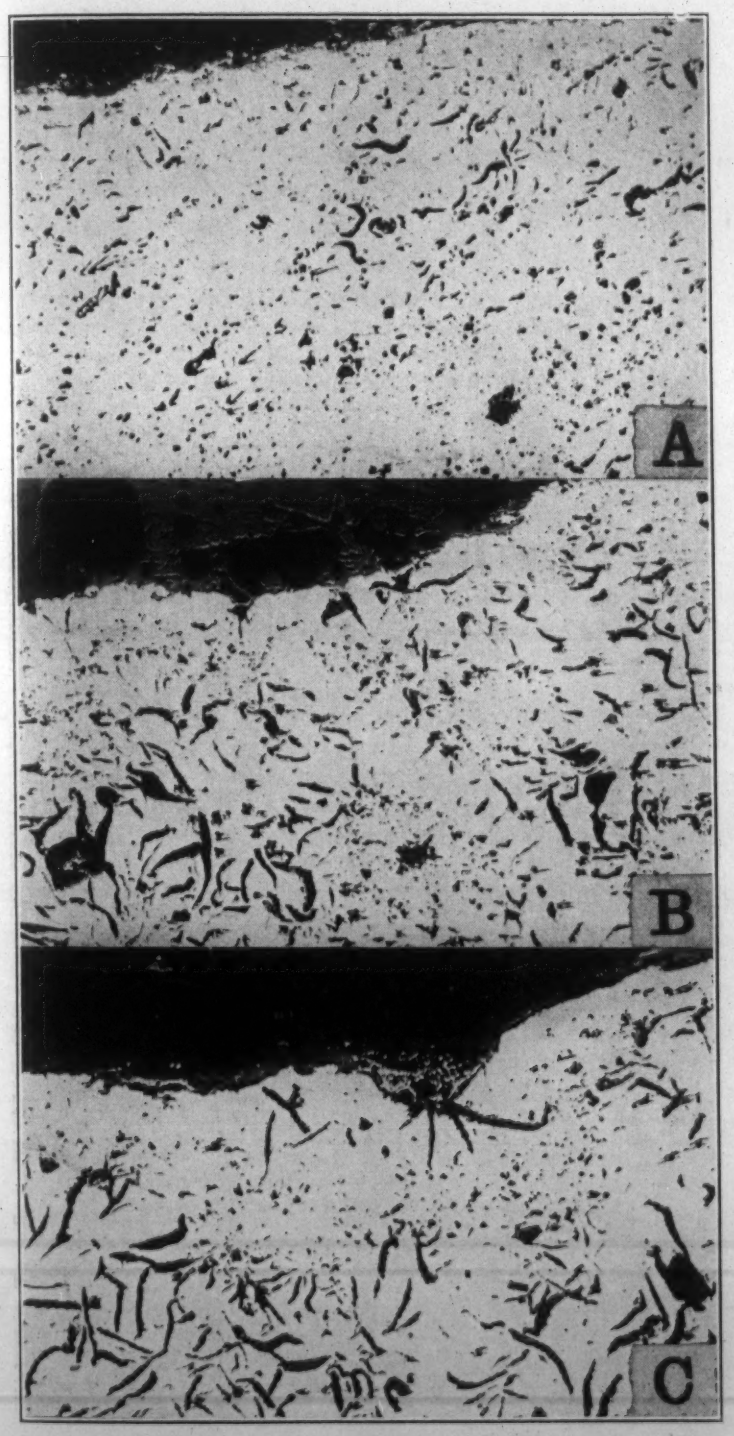


Fig. 4—Iron R_2. Heat 43. Polished, × 100

Illustrating agglomeration of graphite particles upon enameling.
A—Drag side edge of cross section before enameling.
B—Specimen enameled: Ground coat fired 3 min. at 875° C. (1605° F.); cover coat 8 min. at 800° C. (1470° F.). No blisters were observed.
C—Specimen enameled: Ground coat fired 10 min. at 875° C. (1605° F.); cover coat 8 min. at 800° C. (1470° F.). No blisters were observed.

The enameling process is a short anneal, involving decomposition of cementite and agglomeration of graphite. In Fig. 4 this change is noted progressively as the structure in A is changed to that in B and C on heating equivalent to enameling.

A decrease in hardness by enameling has been noted and corresponding changes in structure observed. A specimen which before enameling contained a lamellar pearlite matrix throughout its section (Figs. 5A and 5B) showed after enameling the large ferrite areas and dendritic structure similar to those presented in Fig. 5C and 5D. The remainder of the ferrite was usually spheroidized or changed to sorbite.

In some cases of weakly blistering iron it was noted that but little structural change took place on enameling. In other cases marked changes in structure were noted.

The habit of the graphite, i. e., whether in fine flakes, slightly agglomerated or definitely agglomerated in "whirl" form, was not found to be definitely related to blistering.

"Burning out" the casting before enameling removes some of the surface layer by oxidation, softens by decarburization the metal beneath the oxide coat and softens the metal as a whole. These conditions promote more effective removal of the surface by sand-blasting.

The formation of the microchill appears to be a matter of delicate balance. In view of this can the composition of blistering irons be adjusted so that the microchill will not form, or will not be too deep or hard to be removable by ordinary sand-blasting? The addition of certain well-known graphitizing agents indicated some improvement, particularly in the case of silicon. The microchill appears to be more difficult to prevent than the ordinary chill, though it may be assumed that changes which tend to prevent the formation of ordinary chill would also be steps in the right direction in the prevention of the microchill.

Summary.—The following explanation of blistering is the only one known to the authors that fits the observed facts.

(1) Physically defective castings and improper enamels are causes of blisters. Differences in the tendency of sound castings to give blisters when enameled under identical conditions also exist. The blisters are formed by carbon monoxide and carbon dioxide.

(2) A gray iron of composition normally used for enameling acquires in its making a thin skin or microchill which varies in resistance to removal by sandblasting. Removal of this surface layer eliminates blistering of the type under consideration. The analyses of surface layers suggest its resistance to abrasion may be due to higher combined carbon or some other hard component.

(3) The cementite of this layer tends to break down to very finely divided "temper" carbon, which is more readily oxidized than massive graphite or combined carbon.

(4) This breakdown and subsequent oxidation leads to the formation of carbon monoxide and carbon dioxide by the heating characteristic of enameling and if conditions are such as to cause the final entrapping of these gases in the enamel blistering results.

(5) There are probably two kinds of non-blistering iron; (a) that containing a small amount of combined carbon in the surface layer; (b) that in which the cementite is stable enough not to break down during enameling.

(6) Decarburization of the skin will eliminate the source of temper carbon unless the nature of the whole casting is such that the body as well as the skin will give temper carbon on enameling. The gas evolution which takes place during the first part of firing has been assumed to be due mainly to sub-microscopic graphite which burns out too quickly to cause blistering.

(7) The presence of a hard surface layer probably accounts for the most of the apparently inconsistent results obtained in early experiments in which the microchill was not taken into consideration.

(8) The use of such materials as tend to minimize the tendency of iron to chill may be beneficial, but it is much more difficult to prevent the formation of the microchill than the ordinary or macrochill.

(9) The most promising procedure for processing sound castings that tend to blister is burning out and deep sandblasting.

Comments.—The authors are to be complimented for their contribution to the ultimate solution of a problem which has been

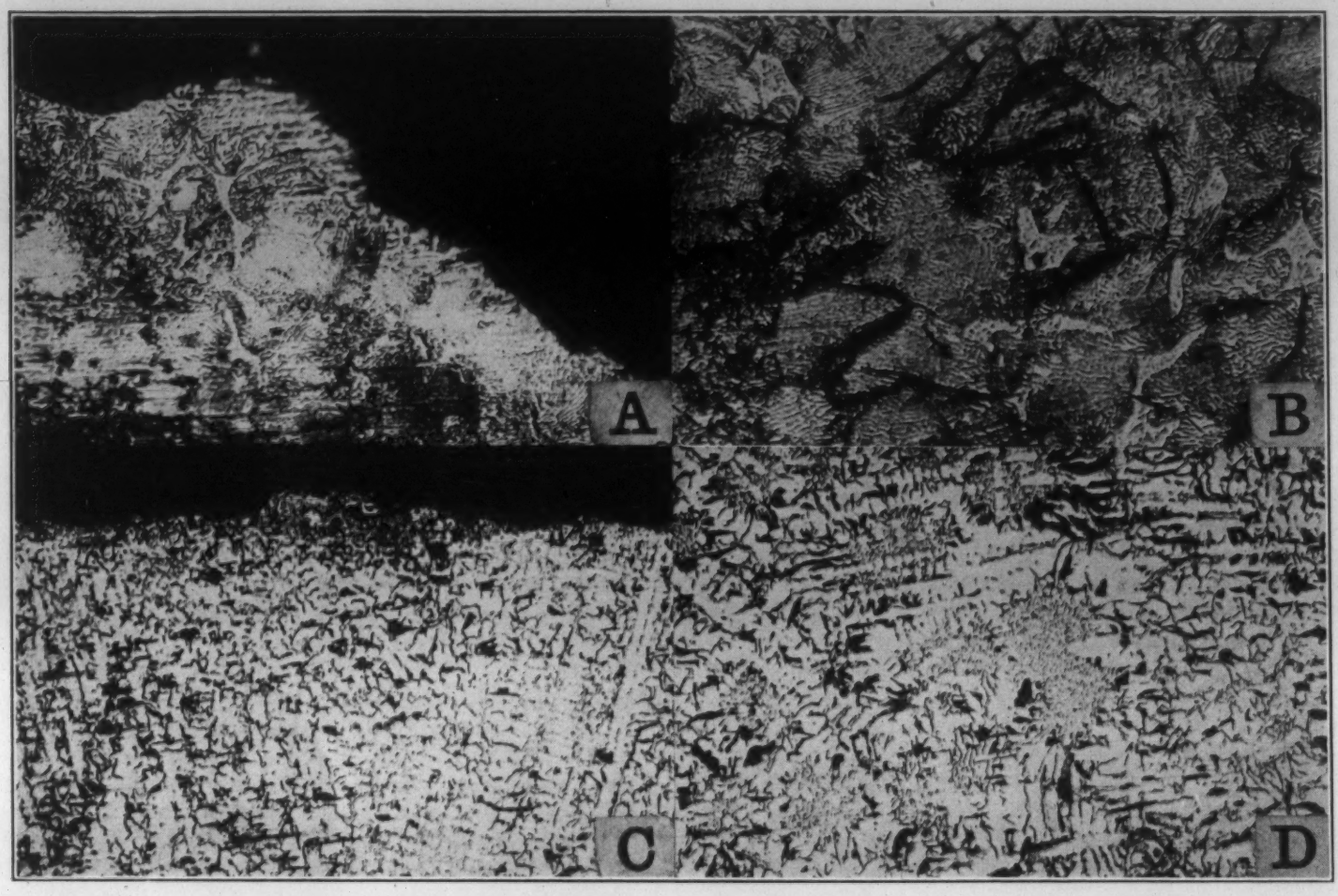


Fig. 5—Iron L_2. Heat 16. Etched in 5% Picric Acid

A and B specimen before enameling.
A—Cross-section at drag side, × 500.
B—Cross-section near center of casting, × 500.
C and D—After enameling, × 100.
C—Part of cross-section adjacent to enamel.
D—Central part of cross-section. A number of blisters were observed on this specimen.
Ground coat fired 8 min. at 870° C. (1600° F.) and cover coat 7 min. at 840° C. (1545° F.).

of much perplexity to enamelers. While some may feel that the work to-date has not produced a workable "cure-all" for blistering of the type under consideration, it must be realized that only correct conclusions can contribute to the practical solution of the problem and a recognition of the fundamental principles involved is the foundation on which the final answer must rest.

Recognition of the fact that gray iron is a complicated system of components which may undergo important structural and chemical changes during enameling is essential to an understanding of the relation between iron and enamel. The literature contains many references to the effect of heat on iron from the point of view of "heat resisting" castings. A few published records, the work presented by the present authors and certain unpublished data from other laboratories indicate many points in common to the two problems.

Pearlitic irons stable to heat have been found to enamel successfully. Hypereutectoid irons and pearlitic irons unstable under heat have been recognized as tending to blister. Structural changes similar to those indicated in Fig. 5A and 5B have been observed as characteristic of unstable irons during enameling.

The theory that changes in the surface layer of the more common types of iron are responsible for a definite type of blistering is a new contribution to our knowledge of the subject but is entirely in line with the few other observations that have been made known. It is to be hoped that the study from this point of view will not be allowed to rest in its present stage but that further work will lead to an application of the correct principles which will make possible the practical control of the properties of the iron without necessitating additional burdens in enameling technique.

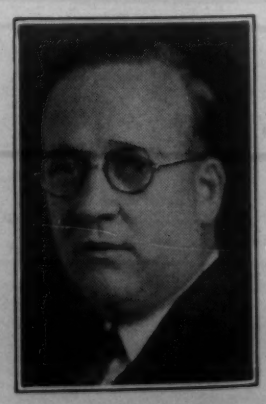
Editor's Note: As Mr. Poste states, some enamelers do not consider deep sand-blasting a cure-all and some of them think the explanations somewhat fantastic. However, we have seen reports from a firm doing enameling on a very large scale (which reports are not available for publication), showing that removal of the surface cured blistering in a very large majority of the cases met in their practice.

It seems doubtful if one is likely to find any simpler or cheaper method of curing blistering than by merely carrying the sand-blasting—an operation that has to be performed anyway—far enough to remove the thin offending layer.

The Steel Founders' Society of America, Inc., has gathered facts and figures on a large percentage of the steel foundry capacity of this country and Canada. Questionnaires were mailed to all foundries in the United States and Canada calling for data on average number of employees, capacity, production of carbon, alloy and heat and corrosion-resisting castings, number and types of furnaces used and other information thought to be valuable to the executives of steel foundries.

The results, as tabulated, include all but a few foundries with small capacity and output, which would in no way change in general the facts revealed by the survey. This data fills 170 pages and is entitled "1930 Directory of Manufacturers, Steel Castings, Heat and Corrosion Resisting Castings in the United States and Canada." Copies of the section of the directory devoted to statistics will be sent on request to Steel Founders' Society of America, Inc., 932 Graybar Bldg., 420 Lexington Ave., New York, N. Y.

Merchandising and Advertising of Steel Castings



Roger L. Wensley, President of G. M. Basford Co., New York, N. Y., delivered an address before the mid-summer convention of the Steel Founders' Society of America, Inc., at White Sulphur Springs, W. Va., on June 16, entitled "Some Phases of the Merchandising and Advertising of Steel Castings."

Copies of this address can be obtained by addressing the Steel Founders' Society of America, Inc., Room 932, 420 Lexington Ave., New York, N. Y.

Correlated Abstracts

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers.

Cadmium vs. Zinc Plating, and the Status of Salt-Spray Corrosion Testing

In the Research Bulletin of the New Jersey Zinc Company for November, 1929, on the Plating of Rolled Zinc and Zinc Base Die Castings, by E. A. Anderson and C. E. Reinhard, there are some comments that are of distinct interest.

This bulletin deals concisely with the polishing, cleaning and plating of rolled zinc and zinc base die castings. A primary coating of Ni is advised because of the ready diffusion of Cu, Ag, Au, etc. Directions are given for plating Ni on Zn, and, as coats to follow Ni, for Cr, Ag, Au, Cu, brass and "bronze." Direct plating of Cd direct on die castings is sometimes used to improve appearance.

The most interesting part is the last section, on tests to determine the properties of plated coatings. We quote this in full, as follows:

"The outdoor exposure test is probably at present the only valid test of the endurance of a plated coating in service. Such tests when continued for twenty-four hours a day so as to include the very corrosive effect of early morning dew will yield results in a comparatively short time. Except in abnormally dry weather, three or four weeks' exposure will yield surprising results in revealing inferior coatings.

"In the salt spray test, the articles are exposed at room temperature in a fine mist containing 20% of common salt. This test when used for a plant control where samples plated under similar conditions with the same metals are compared serves very well the purpose of revealing defective practice.

"There has been, however, a somewhat natural tendency to accept the endurance of a plated coating in the salt spray as an index of useful outdoor life. A little consideration of the facts shows that this cannot safely be done.

"For example, cadmium and cadmium plated steel exhibit a surprising resistance to corrosion in the salt spray, as compared with zinc and zinc plated steel. In a variety of outdoor atmospheres, however, rolled cadmium and plated cadmium coatings have been found to corrode from three to four times as rapidly as zinc, and the conclusions reached on the basis of the salt spray test have been shown to be misleading. Many other cases exist where the results of the salt spray test are rather unreliable as a guide to the relative outdoor life of different metals and metallic coatings.

"It would not be fair to advocate the complete rejection of the well-known salt spray test, but it is important to point out that the useful life of any plated coating on any base should be determined first by actual exposure tests, following which the continuous quality of the production may be checked daily by means of this test."

Other recent authors do not hesitate to commend cadmium. Hoff[1] compares the properties of cadmium and zinc, and says, "From the foregoing, it would be expected that a given degree of rust protection would be obtained with a plate of cadmium much thinner than that required of zinc. This has been confirmed in practice as well as in experiment." And again, "The fact that a thin plate of cadmium can be used where a plate of zinc several times as thick, in order to provide the same degree of rust-resistance, would involve mechanical difficulties, opens up a large field for its use."

In discussion of this paper, it was pointed out that an Army Air Service publication stated that 0.0003″ of cadmium was equivalent to 0.001″ of zinc.

Another similar recent statement[2] is more guarded. It says that since the rate of corrosion is not the same in different parts of the country, no sweeping conclusions can be drawn, but it is often claimed that 0.0002″ cadmium is equivalent to 0.0010″ zinc.

For use in gasoline tanks, coatings of cadmium and zinc applied by the metal spray process, were compared by Pessel[3] and on the basis of laboratory tests, he considers the cadmium coating worth the extra cost over zinc.

Mitchell[4] says, "As a protective coating, a deposit of cadmium is superior to zinc."

Loven[5] says, "In several cases where cadmium has shown twice the resistance in the salt spray test as compared with other coatings, the open air exposure has shown a value of at least three times that of others under the same conditions."

Watanabe and Tsuchimoto[6] repeat the statement that cadmium should be a more effective protection than zinc.

The same sort of statement is made by a German author[7] who claims that thin cadmium coatings protect iron against rust better than thicker ones of zinc.

Hahn[8] claims that cadmium is the best of all plated coatings for corrosion resistance.

Hogaboom[9] claims superiority for cadmium over zinc in sea water or in sea coast exposure.

Davies and Wright[10] studied cadmium and zinc plated coatings of the same thickness, in four thicknesses ($^1/_{10}$, $^1/_2$, 1 and 2 mils), on steel, in salt spray and in sulphuric acid spray.

In the sulphuric spray, the cadmium gave better protection than the zinc, but in salt spray, the three thinner coatings of zinc gave more protection than cadmium, while the thickest coatings gave about equal protection, with cadmium perhaps slightly ahead.

These authors disagree with Wernick who claimed that a thin deposit of cadmium gave the protection of a thicker coat of zinc. They used the salt and sulphuric sprays to simulate sea coast and industrial attack, but report only laboratory tests.

Wernick[11] has clearly stated the idea we had ourselves before we started to chase the subject down. He says, "The superior corrosion resistance of cadmium deposits as compared with zinc is largely due to its lesser chemical reactivity. It is the ideal protective for ferrous material, since it is nearest to it on the anodic side of the electrochemical series, whereas the potential difference between zinc and iron is quite appreciable. While, therefore, the intrinsic protection afforded by zinc is higher than that which cadmium can give, owing to its greater solution pressure, its rate of preferential or sacrificial corrosion is for the same reason also higher. A smaller amount of cadmium or a thinner deposit can therefore provide the protection afforded by a comparatively thick deposit. This was fully borne out in a series of specimens of zinc and cadmium plating submitted to a number of different corrosion tests. Thicker cadmium deposits give appreciably better protection. A deposit 0.4 mil thick as compared with one 0.3 mil thick provides protection considerably in excess of the ratio of these thicknesses. For efficient protection 0.4 mil is a desirable commercial standard, and it is suggested that the more generally advocated 0.2 mil deposit be reserved for precision work, etc., where the thicker deposit cannot be used."

In view of the marked tendency toward cadmium plating, especially for protection of steel in aircraft, the point raised as to the relative value of cadmium and zinc plating seems to deserve discussion.

[1] C. M. Hoff, "Cadmium, Its Electrodeposition For Rust-Proofing Purposes," *Transactions American Electrochemical Society*, Vol. 50 (1926), pages 301–310.

[2] Editorial, "Answers to Correspondents," *Metal Industry*, Vol. 28, April 1930, page 170.

[3] L. Pessel, "Sprayed Molten Cadmium Coatings in Gasoline Storage Tanks," *Industrial & Engineering Chemistry*, Vol. 22, Feb. 1930, pages 119–121; *Metal Industry*, Vol. 28, April 1930, pages 168–170.

[4] W. E. Mitchell, "Electrolytic Cadmium Plant of the Anaconda Copper Mining Co.," *Technical Publication* No. 320, *American Institute of Mining & Metallurgical Engineers*, Feb. 1930.

[5] O. H. Loven, "Production Methods Used in Cadmium Plating," *Meta Industry*, Vol. 28, March 1930, page 127.

[6] T. Watanabe & C. Tsuchimoto, "Cadmium Plating," *Journal Mining & Metallurgy* (Japan), Vol. 7 (1929) pages 3–10, 34–40.

[7] Anon., "Protective Value of Cadmium Plating," *Metallwaren-Industrie und Galvano-Technik*, Vol. 27 (1929), pages 170–171.

[8] V. Hahn, "Galvanic Coating of Wire with Cadmium" *Wire & Wire Products*, Vol. 5, Feb. 1930, page 45.

[9] G. B. Hogaboom, "Cadmium vs. Zinc," *American Electroplaters' Monthly Bulletin*, Vol. 16 (2) (1929), pages 26–30.

[10] L. Davies & L. Wright, "Protective Value of Some Electro-Deposited Coatings," *Advance Copy* No. 517, *Institute of Metals*, March 1930 Meeting; *Metal Industry* (London), Vol. 36, April 11, 1930, pages 407–409.

[11] S. Wernick, "Electroplating of Cadmium For Rust Prevention," *Journal Electroplaters' and Depositors' Technical Society*, Vol. 4 (1928–29), page 101; *Metallurgist*, Vol. 5, March 29, 1929, pages 36–38.

If the contention of Anderson and Reinhard is true, a lot of manufacturers are getting off on the wrong foot.

It is undoubtedly true that the salt spray test is very much over-rated as a means of evaluating actual corrosion resistance in service. One can see why the Navy might turn to the salt spray test as a logical method, but it does not seem reasonable to expect that it need bear any definite relation to actual service inland.

We are of the opinion that much of the salt spray testing that is done is a waste of time, if not actually misleading. (This can indeed be said of many other accelerated corrosion-testing methods.)

Even the question of evaluating the quality of a cadmium deposit by itself, without reference to any comparison with zinc, seems to be up in the air.

Eckhardt[12] states that the usual salt spray test gives no conclusive results when applied to cadmium plating. Six hundred cadmium plated bolts were mixed, and lots of 100 taken. One lot was subjected to atmospheric corrosion in the industrial section of Cleveland. In 95 days, 5% had shown rust, and in 156 days, all had rusted. The other lots were spray tested with NaCl; NH_4NO_3; NH_4NO_3 + NaCl; and SbCl + HCl. None of the curves bore any definite relationship to the behavior under atmospheric attack. In the NaCl spray the bolts showed up about 500% better than standard purchase requirements. The final conclusion is that no satisfactory test has yet been developed for cadmium plating.

Proctor[13] recommends immersion in hydrogen peroxide and acetic acid as a test for cadmium plating, claiming that a deposit which satisfactorily stands this test will meet any normal specification against atmospheric corrosion.

Both questions, the value of the salt spray test, and the relative value of the two coatings, seemed of considerable importance, and to clarify our own ideas on the subject, we sent a draft of this abstract to a few friends whose attitude we believe to be impartial. The replies were so interesting, that instead of merely revising the abstract, we quote some of the comments below.

One expert in electroplating research, says: "I entirely agree that the salt spray is no necessary criterion of the value of a protective coating, except possibly under marine conditions. On the other hand, I do not know of any conclusive data that show that cadmium is not at least as good as zinc for most conditions of exposure.

"The difficulty with many exposure tests is that these tests have been carried out under limited conditions of exposure, and it is doubtful whether the conclusions apply to other conditions. While I have seen no official reports, I gather that the A. S. T. M. exposure tests are not particularly favorable to the cadmium plating. Here again, it may be doubtful whether the history of these cadmium plated samples is sufficiently known to insure that the results fairly represent the value of cadmium plating.

"I feel that there is a very great need for comprehensive tests to establish, under typical conditions of exposure, such as in the A. S. T. M. locations, the value of cadmium, zinc and other metals for protective purposes.

"I have always felt that one serious indictment against the companies that have advocated the use of cadmium plating is that they have never made conclusive exposure tests and published the results to show the purposes cadmium is suitable for, and those for which it is not suitable.

"There is a great need for a thorough study of the protective value of plated metals."

W. Blum, Chemist
Bureau of Standards

Here is a similar point of view.

"A comparison between the two platings is far from an easy matter. There are so very many factors that enter into the preparation of samples for comparison, such as, for example, the purity of the zinc used, the preparation of the samples before plating which need not necessarily be the same—perhaps one cleaning process is better for zinc and another better for cadmium—, the choice of base metal, brass or steel,—cadmium may give better corrosion-resistant results with one and zinc better results with the other—, and so on, just to mention a few of the factors that must be taken into consideration. When making comparisons between zinc coating and cadmium coating, the zinc at first showed rust spots whereas the cadmium-coated steel remained bright, but after three months or so, the cadmium began to go very fast whereas the zinc-coated steel did not go much beyond the original comparatively rapid stage of disintegration." *Colin G. Fink, Head of Division of Electrochemistry, Columbia University*

[12] K. A. Eckhardt, "Wanted, Satisfactory Tests for Cadmium Plating," *American Machinist*, Vol. 71, Dec. 19, 1929, pages 995–997.

[13] C. H. Proctor, "Electrodeposition of Cadmium," *Metal Cleaning & Finishing*, Vol. 1, Dec. 1929, pages 669–672, 686.

Another plating expert says:

"The relative protective value of cadmium and zinc plating as determined by atmospheric corrosion tests and accelerated tests is still, so far as I know, a highly controversial subject, and therefore one on which further information may be of great value; I personally believe that the salt spray test may be of considerably more value in testing coatings which are more noble than steel than it is for testing coatings such as zinc and cadmium which are less noble than steel. I do not believe that conclusions drawn from tests of the less noble metals can be properly applied to the more noble metals and vice versa.

"There is, of course, the possibility that the salt spray test when applied to zinc and cadmium coatings may not give results in agreement with service conditions. I am distinctly of the impression that this is true of steel plated first with cadmium and then with nickel."

E. M. Baker
University of Michigan

Comments of men who have critically observed both laboratory and exposure tests, follow.

"On the whole, I think the attitude of the New Jersey Zinc Company's representatives is fair and impartial. They do not stress sufficiently, however, according to my view of the matter, the marked variations in ordinary weather exposure in different parts of the country. The reader may not realize the *marked* difference which exists in a locality near some industrial center as compared with the open country or the sea coast, for example. It is to be regretted that the A. S. T. M. exposure test results are not yet reported. The early breakdown of coatings according to locality is very marked.

"I agree entirely with Anderson and Reinhard that the salt spray test (as well as other accelerated methods) has decided merit as a means of plant control for determining the uniformity of the product, hence for revealing defective practice. Only so far as test results are supplemented by exposure, the conditions of which are rather well known, can such test results be interpreted in terms of service life. Even then a rather wide margin must be allowed."

H. S. Rawdon, Chief, Division of Metallurgy
Bureau of Standards

"While I have made no actual comparative tests, I believe that the New Jersey Zinc Company's comment is conservative, especially in regard to their acceptance of the salt spray as a routine test. I place this test in the same category as the Preece test, in that it acts frequently as an anesthetic to the producer, leading him to believe that his product is really better than it actually is. The value of cadmium and zinc plating depends so much on the method employed in preparing the base and actually applying the coating that sweeping generalizations should not be made.

"The theory that cadmium plating should be a better protection than zinc due to its slower rate of corrosion when in contact with iron, falls down in the case of atmospheric exposure, as under these conditions electrolytic protection is unreliable and extends for only a short distance."

E. S. Taylerson, Engineer of Tests
American Sheet & Tin Plate Co.

Railroad men, too, appear hesitant to accept salt spray tests as necessarily representative of service results. The engineer of materials of a prominent railroad says:

"I have been told that, cadmium being quite expensive, the coatings which are commercially produced are very thin and sometimes not very durable. Possibly this is the reason for their lack of success, rather than that, other things being equal, cadmium is not so good as zinc.

"For a number of years I used the salt spray test for comparative purposes but never made a careful comparison on the same material between the salt spray and practical outdoor exposure.

"In general, we try to be very cautious regarding accelerated tests, and avoid those in which the acceleration is severe or there is danger of lack of uniformity in the treatment of the specimens. The alternate dipping test appears to be, at least, as uniform as the salt spray."

Other railroad comments are:

"I do not have any first-hand information on the value of cadmium plating, since we have not had occasion to use such plated ware to any appreciable extent in our work. We have never used the salt spray test in corrosion work, although it was applied some years ago in some paint testing work in an endeavor to determine the value of zinc oxide and inert pigments in build-

ing paint for our Norfolk properties. We were rather favorably impressed with its application in paint testing for seacoast conditions, however, we have little faith in such methods of acceleration as a measure of comparative behavior of metallic coated materials under ordinary atmospheric conditions."

James H. Gibboney, Chief Chemist
Norfolk & Western Ry. Co.

"Our experience with the salt spray test indicates that with a given coating, for example zinc, the test indicates the degree of uniformity of the coating. It does not, in our judgment, indicate the relative merits of coatings of different composition when they are exposed in an atmosphere differing from that of the salt spray bath. It is a well established fact that coatings behave in a different manner in different atmospheres. For example, a coating of zinc exposed in an industrial atmosphere containing sulphur dioxide is attacked, zinc compounds of sulphur being formed, which are soluble, the zinc ultimately being converted to zinc sulphate. Under exposures of this kind, the base metal is rather rapidly denuded of the zinc coating. On the other hand, if the zinc coated product is exposed in an atmosphere relatively free from sulphur dioxide and other industrial gases, and especially where the humidity is relatively high, an adherent coating of basic carbonate of zinc is formed over the zinc coating, and this has a marked protective value. One cannot tell from the salt spray test what action a coating will have when exposed to another kind of an atmospheric test.

"Regarding the relative merits of zinc and cadmium plating, our experience has been rather limited, but both coatings have been somewhat disappointing, the results being rather in favor of zinc.

"We may ultimately find that the relative merits would depend on the character of the atmosphere in which the exposure is conducted. In some of the cases of failure which have come to my attention I have felt that the plated coating was too thin, and this may have been the cause of some of the premature failures reported."

M. E. McDonnell, Chief Chemist
Pennsylvania Railroad

"Our research engineer in charge of metal coating developments states:

"A zinc coating can be expected to fail quicker than a cadmium coating of equal weight in a test such as the salt spray test.

"A given weight of cadmium coating gives longer protection than the same weight of zinc coating, until the coatings fail.

"Cadmium does not protect iron by galvanic reaction, and therefore, after coating failure, it does not protect as well as zinc.

"It is my opinion that in no case should we use the results of an accelerated test such as the salt spray test as indicating the relative merits of cadmium and zinc coatings in service."

Anson Hayes, Director, Metallurgical Research
American Rolling Mill Co.

The statement that cadmium does not protect iron by galvanic action is not in accord with the experimental observations of Rawdon[14] made in half-normal sodium chloride. In this case, a cadmium insert not only protected the surrounding iron but was itself etched, the attack on the cadmium being clearly anodic.

Nevertheless, many of the tables of the voltaic series show cadmium as cathodic to zinc.

Hopfelt[15] states that in normal cadmium chloride solution, cadmium is 0.04 volt more noble than iron, and hence must accelerate, rather than prevent, solution of iron. Nevertheless, it exerts a somewhat stronger protection than zinc, says Hopfelt, so he argues that cadmium dissolved from other localities is deposited over any pinholes in the cadmium coating, and this continuous coating then becomes covered with an adherent hydroxide layer, which is less soluble than zinc hydroxide. The protection due to cadmium is, he argues, due to the hydroxide keeping the electrolyte away from the metal. He scratch-brushed through a cadmium coating till iron was bared in spots. After two weeks in sodium chloride, the bare spots were said to be covered with cadmium. Micrographs are shown which are alleged to prove this.

Further comment from Dr. Hayes seems to clarify the situation. He says

"In the table of standard electrode potentials given on page 433 of Lewis and Randall's 'Thermodynamics,' the values of the standard electrode potentials of cadmium and iron by Wilsmore (1900) are, respectively:

Iron against ferrous ion	0.340
Cadmium against cadmium ion	0.420

"Abegg, Auerbach and Luther (1911) give:

Iron	0.43
Cadmium	0.40

"Lewis and Associates (1921) give:

Iron	0.441
Cadmium	0.3976

"From the number of significant figures given by Lewis, his values are evidently of great accuracy, as he has specialized in this field. The significance of a standard electrode potential consists in finding the electrode potential of the pure metal against a solution of its ions of sufficiently low concentrations as to make the laws of ideal solutions hold perfectly. On the assumption of the logarithmic equation which is used for calculating electromotive forces of concentration cells, they then calculate what the electromotive force would be in a solution of one molal concentration, if the laws of ideal solutions held up under this rather concentrated solution.

"This means, in other words, that cadmium against very low solutions of cadmium ions will show lower electromotive forces than will iron against the same very low concentrations of ferrous ions.

"This certainly should approach the conditions under which cadmium and iron must give service in rain water, or ordinary ground water. Since the presence of a salt like sodium chloride at concentrations as high as 0.5 N will change very markedly the activities of the two ions of ferrous iron and cadmium, I believe that it is understood as likely that the relative values of the standard electrode potentials will give us an idea of the behavior of these two metals in rain water or ordinary ground waters as accurately as would their behavior against 0.5 N sodium chloride solutions.

"Even the considerable difference in potentials between zinc and iron is of little value in protecting the iron at the expense of the zinc, except when the areas of exposed space on the iron are extremely small. Whenever a condition arises in which a considerable area of iron is exposed, the resistance of the electrolyte portion of the circuit becomes so great that at only very short distances from the zinc surface, its protective action, due to its higher electromotive force value, is of essentially no consequence. Personally, I feel that the relative values of zinc and cadmium will be entirely determined by the adhering characteristics of their oxides or their products of corrosion."

Anson Hayes, Director, Metallurgical Research
American Rolling Mill Company

This indicates that in sea water, for example, we may have true electrochemical protection by cadmium, which is anodic to iron in such a solution, while in rain water or the other dilute solutions that would be met in inland exposure, the cadmium is cathodic. From this point of view, a salt spray test for evaluating coatings for inland exposure is most illogical, while it would be logical for marine service.

Here follow kind, though guarded, words for cadmium.

"My work with these metallic coatings was exclusively concerned with Navy work, and we were very much interested in the results of the salt spray. We used a sea salt solution of 4% concentration, and with this, in practically all of our testing work, we found rather close agreement with the results of service trials on board ship. The comparisons of zinc and cadmium plating were very limited, but in them the cadmium stood out, both in the laboratory and in service, as distinctly superior to zinc.

"Of course, this was all a case of attack by chlorides, whereas atmospheric conditions generally involve consideration of sulphates in the attacking medium. It is conceivable that this would greatly alter the results obtained with any group of materials."

Jerome Strauss, Chief Research Engineer
Vanadium Corporation of America

"Our experience with zinc and cadmium has been that we are obtaining much better results from the latter. The use of cadmium plating has practically eliminated our troubles with corrosion of fittings, bolts, nuts and all parts which are plated, with the exception of streamline wire. Unsatisfactory reports from the operating groups were quite frequent when zinc plating was used, but are very rare at the present time. Whether this is due to an inherent property of the cadmium plating or is simply due to the fact that we are getting better plating than we were getting six or seven years ago, has not been established by reports from the Service. We do know, however, that the cadmium plating which we are obtaining from aircraft manufacturers will with-

[14] H. S. Rawdon, "Note on the Protection of Iron by Cadmium," *Transactions American Electrochemical Society*, Vol. 49 (1926), pages 339-349.
[15] R. Hopfelt, "Untersuchungen an Kadmiumüberzügen," *Korrosion und Metallschutz*, Vol. 5, Aug. 1929, pages 176–180.

stand 500 hours salt spray, whereas the zinc plating would not withstand more than a hundred hours salt spray.

"Of course, another great advantage of cadmium plating is the fact that the coating is only about 0.0003 of an inch in thickness, whereas the zinc coating is about 0.0015, and consequently the former can be applied direct to threaded parts and will meet the threaded tolerances without undercutting.

"Personally, I believe the combination of salt spray and intermittent test in 20% salt water are very good indications of the serviceability of platings on aircraft parts. The salt spray test, as a routine test on plated material passing through a factory, in many instances eliminated poor plating. We predicted that nickel plated duralumin would break down within months, after it broke down in the salt spray in 24 hours, and it was noticeable that we had trouble from three to six months after the tanks had been installed in the airplane, despite the fact that they were being used at inland stations and were subjected only to the water and gasoline. We also exposed the electroplated tanks to water corrosion, but there was no acceleration to the test; in fact, the tanks which were partially filled with water and standing in the laboratory lasted longer than the tanks in the Service.

"We compared zinc and cadmium coated specimens in outdoor exposure at Dayton, Ohio. In the case of cadmium, it will change color and the coating oxidizes more quickly than with zinc, but actual protection extends over a period of from two to three years at least. For our particular problem in aircraft, the life of the electroplated parts is relatively short and therefore the superior protection which cadmium gives when sodium chloride is present in the atmosphere is preferable to the slower oxidation which may occur with zinc coatings under the atmospheric conditions at Dayton.

"I do not think most comparisons of the two coatings put sufficient weight on the superior throwing power of cadmium. This is very important for our work, as practically all aircraft fittings are more or less complicated in shape and, therefore, throwing power is almost as essential as resistance to chemical action; in fact it is often desirable to make accelerated tests on samples which indicate this property of the electroplating bath, in order to show the relative merits of different solutions."

J. B. Johnson, Chief Material Branch
Air Corps, Material Div., Wright Field, Dayton, Ohio

Instead of the 0.0003″ of cadmium called for by Army specification 3-100-A, February 15, 1927, the Ohio Brass Company standard is 0.00056″ or 0.4 oz./sq. ft. Weather exposure tests made by the Ohio Brass Company, for which we are indebted to Mr. F. L. Wolf, compared seven pieces of cadmium plating from regular production with ten pieces of commercial zinc plating. The results showed that the first spot of rust on one specimen appeared in the same time, two months, with both platings. The last specimen to show a rust spot showed it in ten months with cadmium and twelve months with zinc, the average time for appearance of the first rust spot was the same, six months, in both sets of specimens.

Final failure occurred over a range of three to thirteen months with zinc, six to seventeen months with cadmium, the average—seven months for zinc, eleven for cadmium—indicates a 50% better life for cadmium.

It should be noted that these cadmium deposits were thicker than those often used. Unfortunately, the actual thickness of the coatings subjected to the exposure tests, was not determined.

Agreement with the sentiments of Anderson and Reinhard, is in general, expressed in the following comments from large users.

"Our experience has been in accord with the statements in the abstract both with respect to the value of salt spray results and the service value of zinc and cadmium plating.

"Our testing department observed and reported many years ago the excellent results obtained with cadmium plated articles in the salt spray test. Wisely, however, such tests were checked against outdoor exposure results and found to bear no direct relation to the latter. Whereas the life of cadmium plated iron and steel specimens in the salt spray box exceeded that of the zinc coated specimens, the reverse was found to hold in the outdoor exposure tests.

"The extensive use of cadmium plating to-day is, I believe, due to the superior 'throwing power' of cadmium solutions, making it possible to secure an effective coating in certain types of work, such as the 'barrel process,' where difficulty would be experienced with zinc.

"The work of A. S. T. M. Committee B-3 has shown that, with the knowledge and experience available to-day, it is impossible for several laboratories running salt spray tests to check each other's results with any reasonable degree of accuracy. It is hoped that the information which the committee is slowly accumulating will eventually lead to corrosion tests which will be accurate, consistent and bear a definite relation to what may be expected in service."

T. S. Fuller, Research Laboratory
General Electric Co.

"In general, our experience checks both with the bulletin of the New Jersey Zinc Company and the comments of the abstractor.

"In a few cases, we have used cadmium plating where the color obtained with cadmium was more attractive than the color obtained with zinc. However, our experience has made us believe that in actual service the same thickness of zinc is at least as good a protection as cadmium, and since cadmium is more expensive than zinc, it has been our belief that it is an economic mistake for us to use cadmium where we are not required to use it from the standpoint of appearance.

"Our records indicate that the salt spray test, or, in general, any accelerated test which we have ever seen cannot be used as a true measure of the resistance of a plated coating to outdoor exposure.

"The value of a salt spray test is that it enables us to check uniformity from day to day, but the standard which we try to keep uniform must be established by actual service data supplemented by outdoor exposure.

"In addition, we find that outdoor exposure is not an absolute measure of durability in service. For example, a very thin coating may be durable on outdoor exposure, but may fail from the mechanical action of polishing in service. In addition, a plate of normal thickness or even a material such as stainless steel may develop a few rust spots on outdoor exposure and these rust spots may look very bad, yet the same material in actual service with a more or less irregular washing or polishing, may stand up in a satisfactory manner. This latter case may be checked by examining radiator shells which have been in service on automobiles for two or three years. Their appearance will be very much better than that of similarly plated material exposed a much shorter time."

H. C. Mougey, Research Laboratories
General Motors

"I believe the warning concerning unrestricted use of the salt spray test is very appropriate. Also, I think the doubts raised regarding the protection afforded by cadmium as compared to zinc are well founded.

"On two occasions we have made comparisons of cadmium plating and zinc plating in actual outdoor tests. In both instances, we have been interested in comparing thinly plated coatings ($^1/_{10}$–$^1/_4$ ounce per square foot in thickness) of the order used in finishing small telephone equipment housed indoors. The samples selected for test were companion samples in shape and dimensions, and were prepared to carry the same weights of cadmium or zinc. In both instances when exposed on the roof of our building at 463 West Street, the cadmium plated samples rusted more quickly than the zinc coated ones.

"In one series of these tests, we compared in the salt spray test samples of the same type that were exposed on the roof. In this artificial test, we found that the cadmium promised to last three or four times as long as the zinc.

"The outdoor tests of Sub-Committee VIII of Committee A-5 of the A. S. T. M., when published, will offer some data comparing cadmium plated and zinc plated hardware. The tests at this time are incomplete."

C. D. Hocker
Bell Telephone Laboratories

Further comment from the same laboratory follows:

"We concur with those who are of the opinion that the results of a salt spray accelerated corrosion test must be interpreted with considerable caution. We have come to believe that an accelerated laboratory corrosion test must closely simulate the actual exposure conditions to be met with in service to be at all reliable. This does not mean that the salt spray test does not have a certain usefulness such as a comparative inspection test for control of a given product, as a simulation of sea coast exposure or perhaps in certain cases as a check on the porosity of certain protective coatings.

"Considerable information is available showing that in a salt spray test cadmium coatings last considerably longer than do zinc coatings. However, we have found that in the industrial atmosphere of New York City electroplated zinc loses weight approximately one-half as fast as does electroplated cadmium. This certainly shows that the salt spray cannot be relied upon to judge the serviceability of coatings of different metals.

"We are planning to publish an article giving our tests made to determine the relative rates of weathering of electroplated zinc and cadmium coatings when exposed to a severely industrial atmosphere, a type of service condition which is quite commonly met with, we believe, throughout the United States. We anticipate the paper will appear some time this summer."

C. L. Hippensteel and C. W. Borgmann
Bell Telephone Laboratories

There is obviously much to be said on both sides, and it is to be hoped that more will be said at the symposium referred to below.

"The statements in regard to the durability of cadmium plating are rather conflicting. The American Electrochemical Society is staging a symposium on material for automobile construction, including various kinds of protective plating. This will take place in Detroit next September, and should provoke a considerable amount of interesting discussion, tending to clear the air on this subject. It is hoped in this way to draw out some of the information which is locked up in the laboratories of the automobile companies on this subject."

F. N. Speller, Director, Dept. of Metallurgy and Research
National Tube Company

Recent publications add some information not available when the replies cited above were made. Siemens[16] again repeats the statement that a cadmium plating need not be more than half as thick as a zinc one to give the same corrosion resistance.

Rawdon[17] has canvassed aircraft manufacturers in regard to accepted methods of corrosion prevention, and finds zinc or cadmium plating in favor for steel aircraft parts, with the preference somewhat in favor of cadmium. However, in one case it was necessary to change from cadmium plating to dip-coating with zinc to give adequate protection for a hydroplane.

A report[18] on the A. S. T. M. exposure tests that deal with cadmium has now been made, on 69 weeks of exposure, but in qualitative terms only, as the weights of the coatings have not yet been determined on the duplicate specimens. The report states:

"Of the electroplated coatings, zinc has stood up better than cadmium. Several of the electro-zinc coatings are still in good condition, while others show considerable rust.

The cadmium plated samples showed evidence of breakdown at the first inspection, and generally speaking, seemed to be in the poorest condition of all the specimens on the racks. Breakdown of the electroplated samples invariably started in the depressions or recessed parts of the specimens, indicating non-uniform deposition of metal due to the 'throwing-power' of the solutions."

Patterson[19] reports on 0.65 mil Cd and 0.70 mil Zn coatings exposed indoors, in an atmosphere free from pollution. Corrosion products continued to form on the zinc during the 250-day exposure, corrosion apparently going on at the same rate at the end as at the beginning, while the attack upon the cadmium, though initially more rapid than on the zinc, soon slowed up. Under these conditions, the cadmium appeared superior.

In a very humid indoor atmosphere over a swimming bath with traces of chlorine in the atmosphere, the attack on both the zinc and the cadmium went on at a rather uniform rate, that is, the more rapid initial attack on the cadmium kept up, and the zinc appeared superior, over a 272-day test.

In outdoor exposure in London where the rain water, as Patterson terms it, "consists of a very dilute acid solution," the products of corrosion on the cadmium are readily removed by rain, while on zinc they remain as a partially protective coating. In a 267-day test, the losses in weight were as follows, in mg./in.^{2}.

	Zinc Plating	Cadmium Plating
93 days	2.4	9.7
185 days	14.8	43.9
267 days	19.6	72.7

The conclusions are:

"Both cadmium and zinc form excellent protective coatings for appliances to be used for indoor work. Both should be durable and satisfactory. For outdoor exposure or for severe indoor exposure, there appears to be a strong case for zinc in preference to cadmium."

Atmospheric conditions appear to play a major part. There seems to be room for argument and still more for controlled exposure tests on platings of known thickness and quality in various localities, but on the whole, our former faith in the alleged superior qualities of cadmium coatings has been a bit shaken. We imagine that a good many pertinent data are in existence which have not yet been published, and should like to have the comments of others among our readers who can speak from experience on this subject, as users of zinc and cadmium plating.

H. W. GILLETT

[16] A. Siemens, "Cadmium as a Protection against Corrosion," *Metal Industry* (London), Vol. 36, May 2, 1930, page 481; *Zeitschrift für Elektrochemie*, Vol. 36 (1930), page 101.

[17] H. S. Rawdon, "Corrosion-Prevention Methods as Applied in Aircraft Construction," *Preprint* 33, *Symposium on Aircraft Materials*—for *American Society of Testing Materials*, 1930 meeting, pages 30–36.

[18] "Report of Sub-Committee VIII of Committee A-5, on Field Tests of Metallic Coatings," *Preprint* 13 for *American Society of Testing Materials*, 1930 meeting, pages 18–23.

[19] W. S. Patterson, "The Resistance of Electrodeposits to Corrosion, with Special Reference to Cadmium and Zinc." Paper before Electroplaters' & Depositors' Technical Society, *Metal Industry* (London), Vol. 36, May 16 & 30, 1930, pages 527–529, 579–582.

Continuous Electric Melting of Cast Iron

By H. W. Gillett

Batch melting of cast iron in the electric furnace or the superheating and refining of cupola metal in the electric, in which the furnace is emptied at each pour, has been practiced for perhaps fifteen years. Synthetic electric pig iron, made from steel borings, served a useful purpose during the war, and that type of practice is now applied to the melting of low-carbon, high-test iron in competition with the cupola melting of charges of steel scrap, being especially applicable to the utilization of borings.

The realization of the importance of superheating for dissolving graphite in the melt and thus avoiding the presence of nuclei of free graphite during freezing, has opened up a special field for the electric furnace because of the greater ease with which high temperatures can be reached and controlled in the electric. The effect of superheating, together with other factors not yet fully understood, lead to increased density, tensile strength and deflection of electric iron compared with cupola iron of the same composition.

Specialties, such as sand-cast piston rings, end bell castings for electric motors made from recarburized silicon steel scrap, special alloy irons such as non-magnetic high manganese nickel iron and corrosion resistant high-silicon cast alloys are commonly made by electric batch melting.

Recent developments in continuous melting of ordinary grades of iron give more of a tonnage and less of a specialty slant to the use of the electric furnace for cast iron. Two recent articles, one by Simpson[1] and one by Turner,[2] record such developments, the former dealing both with continuous duplexing of cupola melting and the continuous melting of cold stock, while the latter deals only with the latter practice.

We quote extensively from Simpson's paper below:

"The iron industry has largely grown up around the performance and limitations of the cupola. The management of the foundry and the routing of the work have been, in most cases, arranged to receive a continuous flow of molten metal during the cupola operation. The electric furnace, when operated on intermittent batch heats, does not fit in so well with the established routine of many iron foundries.

Furthermore, the constantly increasing application of continuous molding with mold conveyor systems, and the use of permanent mold machines, have made a continuous flow of molten metal a necessity. These factors have been responsible for the development of two new methods for the operation of an electric furnace to give a continuous flow of metal during the working day.

The Continuous Duplexing Process

In this process the metal is melted in the cupola with just as little coke as will make it run properly. It is fed into the electric furnace and there steel additions or coke or ferro-silicon and ferro-manganese are added, with other desired alloys, to adjust the composition, and the metal is superheated to the desired temperature. A full bath of metal is maintained in the

[1] G. L. Simpson, "Electric Furnace Iron—a Statement of the Present Status," *Preprint* No. 57-12 for 57th meeting, American Electrochemical Society, May 1930, pages 133–138.

[2] N. L. Turner, "Continuous Melting from Cold Stock of Gray Iron in the Electric Furnace," *Preprint* No. 30-10, for meeting of American Foundrymen's Association, May 1930, 7 pages.

furnace; every few minutes at regular intervals, according to the requirements, a batch of refined and superheated iron is tapped off. This continues throughout the day. At regular intervals also larger batches of molten metal from the cupola are added to maintain the capacity of the bath.

Toward the end of the day the charge of hot metal from the cupola is stopped, and the electric furnace is continually tapped until emptied. The largest installation of this kind in the country is in a plant making automobile castings. Over 300 tons of malleable iron per day are duplexed from a battery of two arc furnaces, which are fed from two 72-inch cupolas lined down to 60″. In addition to superheating from 2550–2850° F. (1385–1550° C.) a certain amount of cold steel is melted into the charge in the electric furnace to control the composition. The power consumption of the furnace in this process has averaged below 100 kw.-hr./ton.

One of the large manufacturers of automobile cylinder blocks is duplexing continuously from a 54-inch cupola lined to 48″. In this case, uniform composition from hour to hour throughout the day is of extreme importance.

A Detailed Duplexing Run

A page from their reports follows: On December 12, 1929, "twenty-three tons of iron were duplexed. The cupola was put in blast at 11:30 in the morning. An hour and a half later 13,000 pounds of cast iron had been run into the electric furnace, 1000 pounds of steel had been melted in, and the first 1000 pounds of superheated iron was tapped out. Every five or six minutes thereafter 1000 pounds of superheated iron was tapped from the furnace. At approximately 15-minute intervals, 2300 pounds of iron was added from the cupola. Two and one-half hours after the first metal was tapped from the electric furnace, the last of the iron from the cupola was added. An hour and a half later the last tap of superheated iron was run from the electric furnace. Power consumption for this short afternoon's run amounted to 130 kw.-hr./ton.

"Eight samples taken at intervals throughout the afternoon showed a maximum variation of 22 'points' in silicon and 13 'points' in carbon. The transverse tests ranged from 4500–5000 lbs./in.^{2}; the deflection amounted to 0.14–0.16 in. The average analysis for the day's run was: Total carbon, 3.07%; silicon, 2.24%; manganese, 0.74%; sulphur, 0.10%."

The Continuous Melting Process

The economics of the case and not the metallurgical considerations, determine whether the iron should be melted in the cupola or whether it should be melted in the electric furnace. It is not alone the balancing of the cost of coke and blast against the price of electric power. The lower overall investment cost, the less floor space required, the smaller labor for operation and maintenance and other factors, under certain conditions point toward continuous melting instead of duplexing.

In this process a cold charge is melted in the electric furnace, and a pool of molten metal is obtained. The composition is corrected, the temperature is raised to the desired degree and a small ladle full of iron is tapped off. Immediately thereafter the equivalent amount of cold metal is charged through the rear door of the furnace. This process is continued with alternate tapping and charging until along in the afternoon, when the charging is discontinued and the furnace is emptied.

The largest installation at present is an 11-ton (per hour) continuous melting electric furnace for malleable castings. There is also a 2-ton per hour furnace feeding permanent mold machines, where gear blanks and thin section machine castings are made in gray iron.

Turner's paper describes the first installation in America of an electric furnace as a melting unit for the production of stove-plate castings.

He says: (We quote nearly verbatim), "A point had been reached at which, on cupola operation, where melting was not continuous, it would have been necessary to materially extend floor space in order to cope with the production necessary for the ever-increasing business. As this was undesirable, a system had to be evolved whereby a greater volume of castings could be obtained from the same floor space.

"As 20–30 tons were not considered high enough tonnages to merit continuous cupola operation, a 3-ton electric furnace was chosen as a melting unit.

"Twenty-one months of operation have shown at least three distinct advantages which have been gained by continuous operation, as follows:

(1) Production of castings has been increased 25–30% under existing conditions, without sand-conveying equipment and working only one shift a day.

(2) The cost of iron at the spout is considerably less than previously obtained with the cupola.

(3) The flexibility of the method has proven very valuable in speeding up production and coping with rush orders.

"We melt approximately 40% of cast-iron borings, which we find an economical and a low-loss raw material, since cast-iron borings in the Ottawa district can be purchased at a much lower price than other scrap metal, and, with the necessary additions of ferrosilicon, ferrophosphorus and ferromanganese, can be converted into a high grade of gray iron at a much lower cost than previously could be obtained with cupola iron.

"The disposal of steel clippings from the sheet-steel department formerly caused a considerable amount of trouble, for the expense of baling and shipping rendered them valueless. However, with the installation of the electric furnace, they have been treated as a raw material, making them part of the first charge. It is inadvisable, however, to melt them in large quantities, owing to their tendency to reduce the carbon content.

"For the twenty-one months of continuous operation, not a pound of virgin pig iron has been charged, producing at the same time a better quality of gray iron than that obtained in the cupola, where a high percentage of pig iron must be used.

"The melting cost per one month's operation is given below. The power cost in Ottawa is relatively low, and this figure will of course vary with the locality. On the other hand, the furnace was operated at a low load factor during the month recorded.

Table I—Cost Summary—Operation of Electric Furnace for One Month

Raw Materials	Lbs.	Cost per Ton	Total Cost	Total Cost per Ton
Stove plate	102,095	$12.50	$ 637.50	
Borings	234,450	10.00	1172.50	
Steel scrap	27,455	....	.....	
Foundry returns	323,285	13.00	2100.80	
Additions	8,290	....	.....	
Total	695,575		$3910.80	$11.25
Additions	**Lbs.**	**Cost per Lb.**	**Total Cost**	
Fe Si	6,350	$ 0.03	$ 190.50	
Fe Mn	750	0.04	30.00	
Fe Ph	1,190	0.06	71.40	
Coke	13,200	0.006	79.20	
Total	21,490		$ 371.10	1.07
Labor			$ 397.72	1.14
Power			1825.55	5.25
Electrodes				2.09
Refractories				0.60
Water				0.11
Laboratory				0.50
Interest on investment, and depreciation				0.57
Melting loss				1.13
Total cost of operations, per ton				$23.71

"One of the main factors contributing to the low cost is the lack of necessity of using pig iron. As No. 1 pig iron at present is $25.00 per ton, f.o.b. Ottawa, this can be recognized readily as an important cost item.

Melting Practice.—"To maintain the continuity of the continuous operation, an initial bath of iron must be built up before the continuous charging and tapping may take place.

"After the last iron is tapped out, the pits are cleaned, the furnace bottom is patched and the first charge—consisting of gangway pig, foundry returns, stove-plate scrap, cast-iron borings and steel clippings—is charged into the furnace.

"At a fixed time, the melters come on duty and commence to melt down the first charge, consisting of three tons. On completion of this operation and when the iron is up to temperature, the furnace is slagged off and more borings are fed in, in suitably sized charges, until a bath of nine tons is built up.

"In charging the feed charges, a division is made and two separate piles are placed, one on each side of the charging door, so that the melter and his helper can feed them into the furnace without loss of time.

Metallurgical Analysis.—"On completion of the melt-down of the original bath, a test bar is poured and a complete analysis is taken before any iron is tapped. This enables the metallurgist to correct any discrepancies in analysis, and to maintain a constant quality of iron.

"When the iron is passed by the chemist and is up to temperature—the temperature being taken by an optical pyrometer—the first ladle is tapped out.

"The first bull-ladel of iron is usually tapped out at 7:00 a.m., to pour off any molds that have been left from the day before or any overtime molding accomplished the previous evening. Sometimes it is necessary to tap out several bull-ladles in succession, to meet with shop requirements, but this serves to stress the advantage of the flexibility of the system in providing iron at any time.

"After a tapping has taken place, a feed charge is charged in, and this operation of tapping and feeding is continued until the necessary amount of iron is obtained for the day's cast.

Feed Charges.—"The feed charges consist of foundry returns and stove-plate scrap, which do not require the addition of any alloys. It is a good practice, however, to mix a charge of foreign stove-plate scrap with foundry returns, because it is found that the former has a tendency to oxidize the iron and reduce the carbon content. With each feed charge, about 1% of ground coke is added to take care of any loss of carbon that may take place in the melting.

"The usual feed charges under present requirements consist of approximately 1100 lbs. of iron, which takes between 15–30 minutes, depending upon the power input. About 1400 lbs. of iron are tapped out. This, however, depends upon shop requirements.

Ideal Analysis of Iron.—"The ideal stove-plate gray iron analysis, for iron melted in an electric furnace, lies within the following ranges:

Carbon, %	3.25–3.35
Silicon, %	2.75–2.85
Phosphorus, %	0.60–0.70
Manganese, %	0.45–0.60
Sulphur, %	Less than 0.09

"With electric-furnace stove-plate iron, it has been found necessary to keep the silicon higher than that of cupola iron, and it should never drop below the minimum outlined above. During the day, however, there is a slight increase in silicon, undoubtedly picked up from the slag and furnace bottom. This, however, can be controlled by the addition of some low-silicon raw material, such as borings.

"During the experimental period, considerable difficulty in keeping up the carbon content was experienced, but this was overcome by the use of the proper amount of ground petroleum coke.

"On continuous operation the refractories do not give so high a tonnage as on batch melting, but the following figures may be considered satisfactory:

Roof, about 650 tons
Lining, about 850 tons

"Until experience was gained, considerable difficulty was experienced in maintaining the bottom."

World Reserves of Tin and United States' Consumption

(*Continued from Page 654*)

reserves of 8192 tons. Practically all production is won from alluvial deposits located on or near the coast and near the southern extremity of the province.

During 1928 the Union of South Africa produced 1257 tons of tin. Of this amount 764 tons came from mines reporting reserves sufficient for 2½ years' production at the 1928 rate. Most of the tin comes from lode mines.

The Unfederated Malay States produced 2433 tons in 1928, the Belgian Congo, 1200 tons, and all other countries 2949 tons; no reserve figures are available for their producing properties, but their nonproducers report a total of 8011 tons of metallic tin in ore blocked out.

There are some facts that stand out fairly clearly as regards tin reserves; the tin famine which has been predicted as imminent for the last few years undoubtedly has been postponed for some years by the flood of new capital which has entered the tin-mining industry during the recent years of high tin prices; all the important alluvial areas are increasing their outputs with each succeeding year; Bolivia, the greatest lode producer, is increasing its production by further development, better technology and improved transportation; and the other lode producers, taken as a whole, are holding their own.

The uses of tin, the highest priced of the common base metals, have been the subject of much study directed toward substitution of the cheaper base metals and of other substances. This search for substitutes will continue to be a factor in the tin situation even with the low prices now current, and expansion of tin consumption to absorb the increasing production must also cover losses in demand due to the substitution of other materials for tin.

The quantity of secondary tin recovered fluctuates with the price of virgin metal. The main sources from which tin is reclaimed are tin plate and tin alloys.

Most of the tin plate entering the reclaiming processes is composed of trimmings incidental to the fabrication of tin-plate products. A small amount of used tin cans also enters the detinning plants. This latter source, though very large is only little used because of the difficulty of collection, the expense of removing objectionable adhering material, and the necessity of sorting out the corroded cans. At present the leading method used for tin recovery from tin plate is the chlorine process, which involves the exposure of clean, dry tin plate to dry chlorine gas. The tin is recovered as the chloride, much of which enters as such into the silk, pigment and ceramic industries. The tin-free steel scrap residue is well suited for charging into basic open-hearth steel furnaces. Other detinning methods of importance are the electrolytic and the alkali methods.

The other great source of secondary tin is the tin-bearing alloys, solder, babbitt, bronze, white metal, type metal and foils. In this field the junk dealer plays a very important part in the collection and classification of material for treatment. The tin so recovered re-enters the trade largely as alloys which have been brought to desired specifications by remelting with added virgin metals as required.

Some tin has been displaced by increasing the lead content of the alloy in the manufacture of terneplate and by the substitution of terneplate for tin plate in some cases. The research being carried on to substitute lacquers for tin in the manufacture of tin cans has made little progress because of the difficulty in obtaining an appearance of cleanliness and beauty equal to that of tin as well as the difficulty in duplicating the purely utilitarian qualities of the tin coating. The greatest savings so far made have been achieved by reducing the thickness of tin coating on tin plate.

The substitution of cadmium for part of the tin in solder has proved satisfactory in some uses. Each unit of cadmium added has the effect of approximately two units of tin, thus allowing lead to displace part of the tin in the solder. The fact that cadmium is a by-product in electrolytic zinc plants indicates that as electrolytic zinc production increases more cadmium is likely to be placed on the market. Cadmium solders would probably be substituted further for tin solders should this increasing production of cadmium at electrolytic zinc plants depress the cadmium price sufficiently.

Aluminum is being used as a substitute for tin in the manufacture of foils and collapsible tubes. The fields where lead is excluded because of its toxic properties are now being invaded by aluminum. According to a recent article, the addition of 0.2% of sodium silicate to ordinary soaps has proved a success in overcoming the pitting of aluminum by such soap. This should increase substitution, particularly in shaving-cream containers. Tinfoil is also meeting competition for use as a food wrapper; for example, from a transparent cellulose product made from wood pulp.

The further introduction of ball and roller bearings, particularly in railroad rolling stock, has cut into fields once held almost exclusively by babbitt and related bearing metals.

The substitution of rayon for silk tends to lessen the use of tin as rayon, unlike silk, does not require the use of tin salts in preparation for dyeing and in weighting.

Fortunate also for future consumers of tin is the fact that many of the uses of tin are not destructive, or are only partly destructive. During 1928 about one-third of the United States' consumption was supplied by domestic secondary tin. Tin entering the alloys is largely recovered to be reused in new shapes after remelting. Practically all tin entering the pigment and silk trades is completely lost when the article containing the tin is finally discarded. That used in the manufacture of tin plate, though at present largely lost, is subject to partial recovery as soon as prices warrant the collection and treatment of discarded tin cans. At present, most of the tin plate clippings, resulting from can manufacture, yield their tin coating for further use.

Further data are given in Information Circular 6249, "World Reserves and Resources of Tin," copies of which may be obtained from the United States Bureau of Mines, Department of Commerce, Washington, D. C.

Louis S. Cates recently resigned the position of vice-president and general manager of the Utah Copper Co. that he had occupied with great success for many years and accepted the presidency of the Phelps Dodge Corporation, succeeding Walter Douglas, who desired to be relieved from executive duty, but who continues as a member of the board of directors.

Translations

The readers of METALS & ALLOYS *will be assured of receiving in this section an extended abstract in English of the best articles appearing in foreign publications.*

The Decarburization of Iron in the Open-Hearth Furnace and the Concentration of Free Ferrous Oxide in Basic Slags*

By Hermann Schenck, Essen, Germany

The chemical reaction during the separation of carbon from ron in the open-hearth furnace may be written as follows:

$$FeO + C \rightleftarrows Fe + CO$$

This reaction is somewhat limited by certain conditions of equilibrium which establish a lower limit for the carbon content, a limit which depends upon external conditions. For a given temperature the position of this limit may be represented by means of the following equation:

$$[\Sigma C] = \frac{p_{co}}{(FeO) \cdot K} \qquad (1)$$

where [ΣC] indicates the total carbon content of the metal, (FeO) the ferrous oxide content of the slag and p_{co} the partial pressure of the carbon monoxide in the gas phase which is in contact with the slag and metal phases. The constant K indicates the variation of the equilibrium with the temperature.

Some investigators have established equation (1) in a somewhat modified form; for instance, the ferrous oxide concentration in the slag (FeO) was replaced by the bath concentration [FeO] thereof, the partial carbon monoxide pressure was replaced by the amount of its concentration dissolved in the metal. In view of the fact that, in accordance with Nernst's and Henry's laws, (FeO) and [FeO], as well as p_{co} and CO, respectively, for a given temperature, are approximately proportional, and further, in view of the fact that the factors of proportionality may be combined with K to form a constant independent of the temperature, a modified expression of equation (1) usually amounts to no more than a difference of form.

We shall assume, therefore, that equation (1) is valid for purposes of qualitative considerations. This equation consequently states that for a given temperature the minimum carbon content obtainable by the open-hearth process is determined by the ferrous oxide content of the slag and the partial carbon monoxide pressure. If the requirements of this equation are satisfied, a condition of equilibrium and of termination of the reaction have been reached; the combustion of carbon takes place only as long as the right side of the equation is smaller than [ΣC]. The converse reaction, that is, the passage of carbon monoxide into the metal under formation of carbon and ferrous oxide, is also conceivable, particularly if by the addition of a strong reducing agent, such as ferro-silicon, (FeO) has been reduced to the extent that the following condition is reached:

$$[\Sigma C] < \frac{p_{co}}{(FeO) \cdot K}$$

In order for the decarburization to take place at a satisfactory rate, the following condition must be satisfied:

$$[\Sigma C] > \frac{p_{co}}{(FeO) \cdot K}$$

that is, there should be a certain departure from equilibrium.

The partial carbon monoxide pressure bears the following relation to the total pressure P of the gas phase, which latter can usually be assumed to be 1 atmosphere, and to the carbon monoxide content in volume percentage:

$$p_{co} = P\frac{CO\%}{100} \sim \frac{CO\%}{100} \qquad (2)$$

There arises the question as to what value is to be given to p_{co} in equation (1).

It is apparent that in the open-hearth furnace the value of this item largely depends upon the nature of the reaction involved. The gas formed in the metal bath has to break through the slag cover. It may be assumed that between the slag and the metal there is formed a so-called "bumper layer" of the gaseous reaction product, essentially consisting of carbon monoxide, with small amounts of carbon dioxide, hydrogen and water. In this case, therefore, the gaseous reaction product which comes in contact with the metal and the slag at the point of reaction would almost entirely consist of pure carbon monoxide, that is, p_{co} would have a value of 1 atmosphere. It is, however, also conceivable that a portion of the decarburization takes place at the drop of liquid metal which during the boiling has been projected through the slag covering to come in contact with the heating gases in which the partial carbon monoxide pressure is almost zero, owing to the almost complete absence of this gas. However, if we assume that there is formed around the iron drops a "bumper layer" of the gaseous reaction products, then again p_{co} may be assumed to be equal to 1. The assumption of the formation of "bumper layers" has a certain appearance of probability; therefore, it would be advisable for the present considerations to give to the partial carbon monoxide pressure a value p_{co} close to 1 atmosphere, which value is to be considered constant.

For these reasons equation (1), by combining p_{co} and K to a constant K′, may be given the following form:

$$[\Sigma C] = \frac{p_{co}}{(FeO) \cdot K} = \frac{1}{(FeO) \cdot K'} \qquad (3)$$

Starting from the assumption that the partial carbon monoxide pressure is always equal to 1, C. H. Herty, Jr., and associates,[1] as well as A. L. Feild,[2] applied a similar expression to the decarburization in the open-hearth furnace. As is the case in investigating the corresponding manganese and phosphorus reaction, it is somewhat doubtful, however, whether or not the conditions under which the experimental facts forming the basis for the laws of equilibrium have been found, really were the true conditions of equilibrium. Unfortunately, the procedure applied in a prior publication,[3] namely, to use the points of reversals of the time-concentration curves as a basis for establishing laws of equilibrium, is not applicable to the carbon reaction, since a reversal of the reaction

$$FeO + C \leftrightarrows Fe + CO$$

from right to left without external influences is hardly noticeable in the open-hearth furnace.

In order to ascertain whether there is any relation between the free iron oxide (ferrous oxide) of the slag and the decarburization of the metal bath, the following investigations were made.

The tests were made in connection with results of measurements obtained with seven 20-ton heats mentioned by F. Körber, and with seven 60-ton heats, investigated by the author. The results of these investigations are tabulated in Tables 4, 4a, 5 and 5a of the above-mentioned paper.[3]

As a standard for the oxidation of the slag is to be considered the concentration of the "free," that is, not chemically combined ferrous oxide (FeO).

In investigating the laws relating to the reactions of manganese and phosphorus in the basic open hearth furnace, reference has already been made to the fact that the opinions as to how the concentration factor (FeO) is to be evaluated are not agreed, and that the following conceptions may be set forth:

1. The total iron content (ΣFe) tobe ascertained by chemical analysis of the slag is to be regarded as having the form of free ferrous oxide.
2. The bi-valent iron content (ΣFe) to be ascertained by chemical analysis of the slag is to be regarded as having the form of free ferrous oxide.
3. The iron oxide content of the slag is a result of a process of oxidation. When in contact with the metal, iron oxide is completely transformed into ferrous oxide ($Fe_2O_3 + Fe \longrightarrow 3FeO$), whereby 1 mol (159.8 parts by weight) of FeO gives 3 mols (215.5 parts by weight) of FeO, which are to be added to the ferrous oxide content which has been determined analytically, according to C. H. Herty and associates.[1]
4. The results of analytical investigations into the content

* Report No. 182 of the Steel Works Committee of the Verein Deutscher Eisenhüttenleute. Translated by special arrangement from the *Archiv. für das Eisenhüttenwesen*, Vol. 3, Mar. 1930, pages 571–576.

of the slag of bi- and tri-valent iron do not correspond to the actual conditions within the furnace, which are still unknown, according to J. H. Whitney.

In *Kruppsche Monatshefte*, Volume 11, 1930, page 1, H. Schenck has sided with the latter conception;[4] he has endeavored, by considering the manganese and phosphorus reaction from the standpoint of the laws of equilibrium, to derive mathematical expressions for the concentration of the free ferrous oxide, under the assumption that the total iron content [ΣFe] of the slag is present partly in the form of ferrite of lime, partly as free ferrous oxide. Consequently the calculation of (FeO) was carried out as follows:

1. Subtraction of the lime combined with the phosphoric acid, $(CaO)_{P_2O_5}$, from the total lime content (ΣCaO) of the slag which is to be determined analytically; thus we obtain:

$$(\Sigma CaO)' = (\Sigma CaO) - (CaO)_{P_2O_5} = (\Sigma CaO) - 1.18(\Sigma P_2O_5) \ldots .$$ Subrelation

2. Calculation of the lime combined with the silicon dioxide, $(CaO)_{SiO_2}$, to be subtracted from $(\Sigma CaO)'$:

$$(CaO)_{SiO_2} = \frac{(\Sigma CaO)' \cdot (\Sigma SiO_2)}{(\Sigma CaO)' + (\Sigma SiO_2)} \cdot \frac{(\Sigma CaO)'^2}{(\Sigma CaO)'^2 + \alpha}$$

$$\text{where} \quad \log \alpha = -\frac{44{,}000}{T} + 26.2$$

$$\text{Hence:} \quad (\Sigma CaO)'' = (\Sigma CaO)' - (CaO)_{SiO_2} \ldots .$$ Subrelation II

3. Graphical determination of (FeO) by means of the equation:

$$(\Sigma Fe) = 0.78(FeO) + \frac{0.52(FeO)^3\,(\Sigma CaO)''}{0.26(FeO)^3 + \gamma}$$

$$\text{where} \quad \log \gamma = -\frac{48{,}600}{T} + 28.8$$ Subrelation III

The four conceptions above were then examined in a purely graphical manner by plotting the carbon content of the metal samples taken from the melt as a function of the ferrous oxide content of the slag which had been calculated in different ways (see Figs. 1 to 4). Various designations were used for the data according to temperatures grouped from 20 to 20°; the Krupp (60-ton) heats were also differentiated from the Körber (20-ton) heats.

In Fig. 1 the scale of the abscissa is the proportional concentration of the total iron content (ΣFe). It is seen that neither conception 1 nor conception 2, Fig. 2, indicates any relation between carbon content and ferrous oxide content of the slag.

The same thing applies to the Herty conception (Fig. 3). Even the choice of the theoretically more accurate concentration constant "mols FeO" is unable to accentuate any particular laws and relations. The curves plotted are designed to represent equilibrium conditions at various temperatures, in accordance with Herty's method. These curves have no relation to the data found experimentally.

It is to be noted that those groups of dots which at high carbon concentrations are located to the extreme right of Figs. 1 to 3, are usually associated with slag samples having a high lime content and a low silica content. Therefore, slags with a higher basicity should indicate a higher total iron content than those with low basicity in order to be able to oxidize carbon equally effectively.

The fourth conception of the concentration of the free ferrous oxide which has been quantitatively expressed in the sub-relations I–III, clearly shows the influence of the relation between [ΣC] and (FeO), (see Fig. 4); it is not to be expected a priori that the law should appear with absolute clearness, since this would require as a prior condition the establishment of a condition of equilibrium which cannot be expected.

The relations between the carbon content of the metal and ferrous oxide content of the slag calculated from the above-mentioned sub-relations become more distinct as soon as one analyzes the individual temperature ranges (Figs. 5a to 5f). The dots or points corresponding to each range in this case assume the approximate form of a hyperbolic curve. The combination of the individual curves (Fig. 6) shows that the slags corresponding to a given carbon content contain the more free ferrous oxide the higher the temperature. Owing to the continuous increase in temperature the group of curves when applied to the decarburization process assumes an average approximately as shown by the dotted line. It is noteworthy that the equation of these curves (Figs. 5a to 5f) do not correspond to an equation of the form

$$\frac{1}{(FeO)\,[\Sigma C]} = \xi^4 \qquad (4)$$

for the reason that the curves are too steep. One might conclude from this that ξ itself is a function of [ΣC], in such a fashion

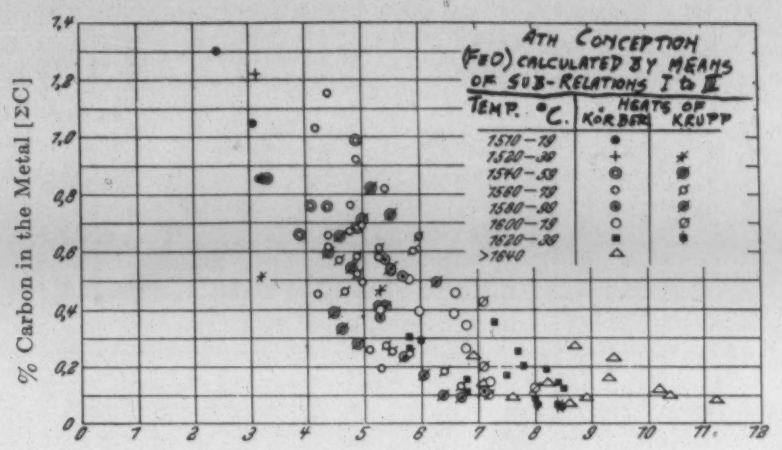

4TH CONCEPTION
(FeO) CALCULATED BY MEANS OF SUB-RELATIONS I to III
TEMP. °C.
HEATS OF KÖRBER
HEATS OF KRUPP
% Carbon in the Metal [ΣC]
% Free Ferrous Oxide in the Slag (FeO)

Fig. 1—Attempt to Represent the Relation between the Carbon Content of Open Hearth Heats and the Ferrous Oxide Content of the Slag according to the Fourth Conception (H. Schenck)

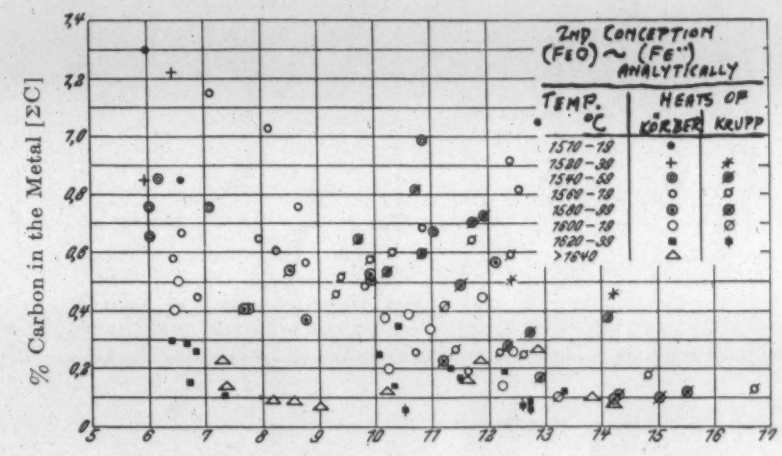


Fig. 2—Attempt to Represent the Relation between the Carbon Content of Open Hearth Heats and the Ferrous Oxide Content of the Slag according to the Second Conception

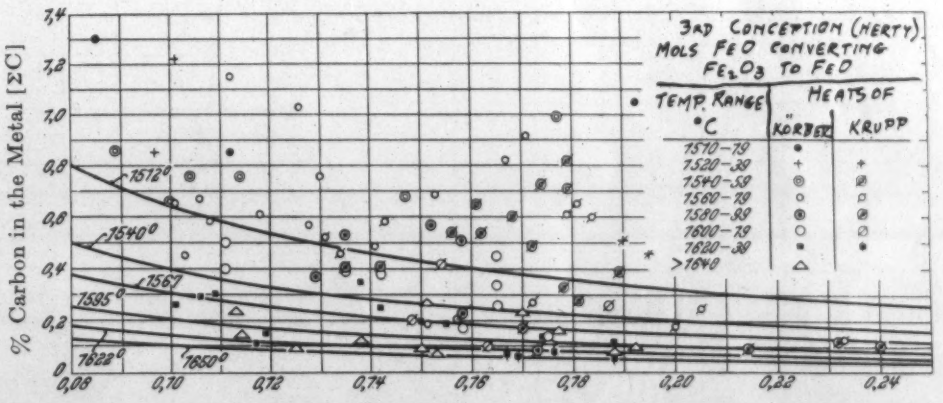

3RD CONCEPTION (HERTY)
MOLS FeO CONVERTING Fe2O3 TO FeO
TEMP. RANGE °C
HEATS OF KÖRBER
HEATS OF KRUPP
% Carbon in the Metal [ΣC]
Mols Ferrous Oxide in the Slag in %

Fig. 3—Attempt to Represent the Relation between the Carbon Content of Open Hearth Heats and the Ferrous Oxide Content of the Slag according to the Third Conception (Herty)

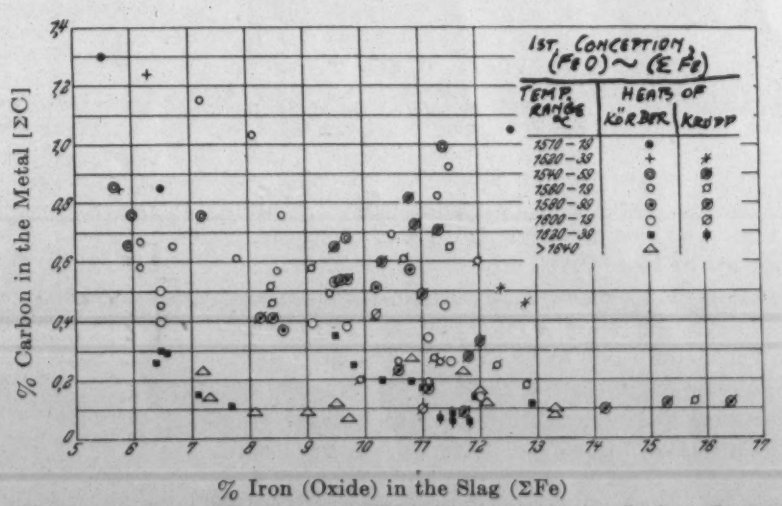
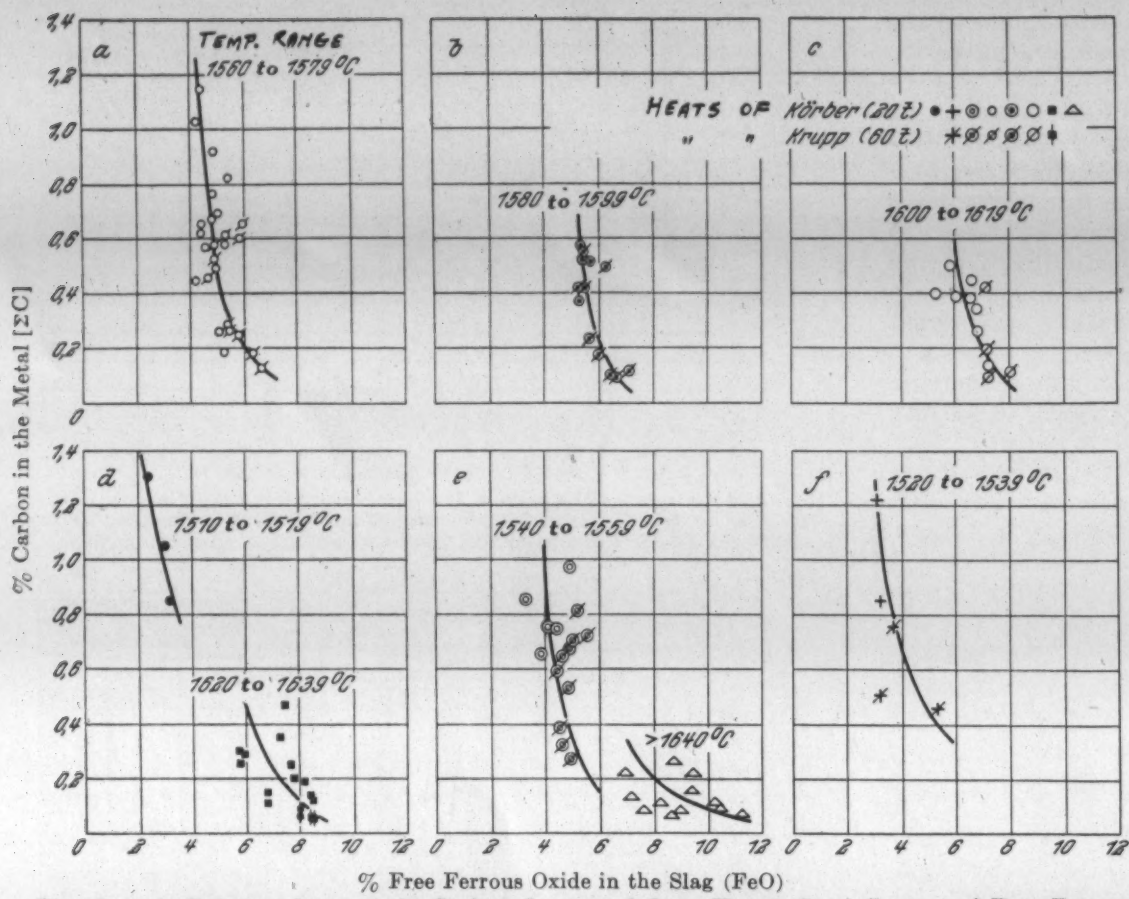


Fig. 4—Attempt to Represent the Relation between the Carbon Content of Open Hearth Heats and the Ferrous Oxide Content of the Slag according to the First Conception



Figs. 5a to f—Relations between the Carbon Content of Open Hearth Steel Content of Free Ferrous Oxide of the Slag Calculated according to the Sub-relations I to III

assumed to correspond to p_{co} constant at about 1 atmosphere, actually corresponds to the facts. The velocity of decarburization and consequently the amount of carbon monoxide developed generally decreases with decreasing carbon content. If it is now assumed that the "bumper layer" more and more loses its action of preventing the furnace gases from flowing to the point of reaction by the decrease of the amount of carbon monoxide developed by the reaction, it must then, of necessity, be concluded that with decreasing carbon content the magnitude of the partial pressure p_{co} contained in K and ξ should also decrease. In this case the ideal law of mass action would preserve its validity also for the processes prevailing here; however, it should be used in the following full form:

$$\frac{p_{co}}{[\Sigma C]\,(FeO)} = K$$

An endeavor to include the velocity of decarburization in these relations for the purpose of a practical application of the above theory was unsuccessful. In a certain sense it was possible to note a relation; however, this relation was too vague to be susceptible of numerical expression. This is due to the fact that it is very difficult to derive the instantaneous velocity of decar-

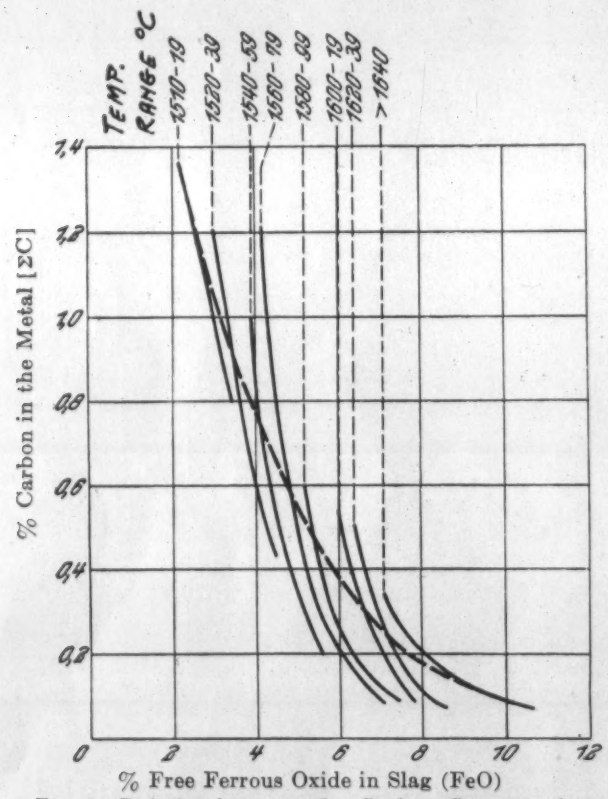
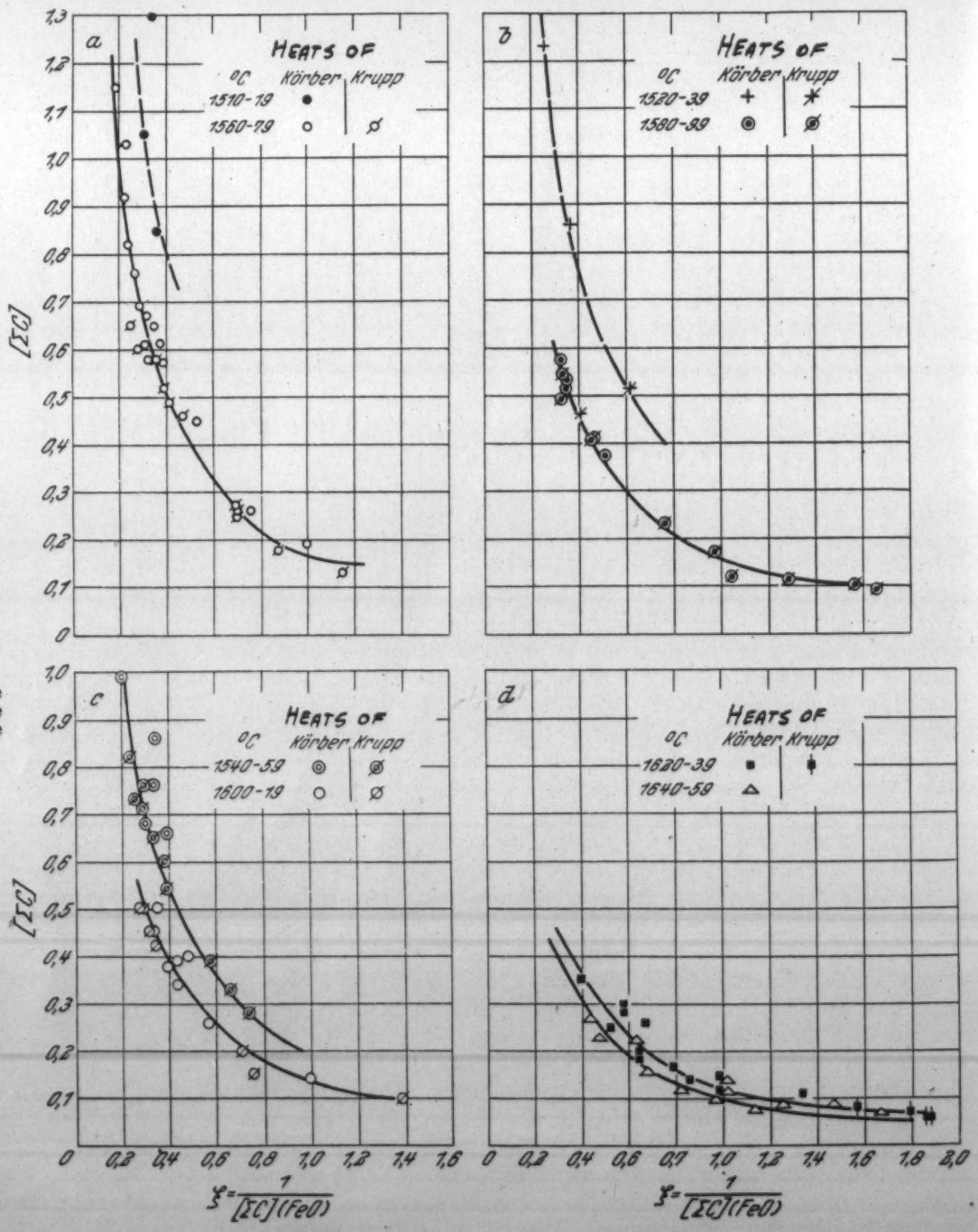


Fig. 6—Relation between the Carbon Content of the Open Hearth Steel and the Concentration of the Free Ferrous Oxide in the Slag (Calculated by Means of the Sub-relations I to III) at Various Temperatures

that ξ decreases with increasing carbon content. The relations between [ΣC] and ξ are clearly shown in Figs. 7a to 7d.[5]

It is not yet entirely clear in which manner this relation should be explained. In the first place it may be considered to be very probable that the experimental data do not entirely correspond to the condition of equilibrium. If it be assumed, however, that the curves represented in Figs. 5a to 5f are almost parallel to the equilibrium curves located to their left, then it should be concluded that the ideal law of mass action no longer fully applies to the range of concentration under consideration. However, there would still be another possible interpretation; it is not clear whether or not the theory of a "bumper layer" of pure carbon monoxide at the point of reaction, which has been



Figs. 7a to d—Dependence of the equation $\frac{1}{[\Sigma C]\,(FeO)} = \xi$ upon the Carbon Content of the Metal at Different Temperatures

Table I—The Concentration of "Free Ferrous Oxide" (FeO) in the Slags at Various Temperatures (Calculated by Using the Sub-Relations I to III)

Slag Constituents in Percent by Weight			Temperature in ° C.						Slag Constituents in Percent by Weight			Temperature in ° C.					
(Σ Fe)	(ΣCaO)′	(ΣSiO₂)	1527	1552	1577	1602	1627	1652	(ΣFe)	(ΣCaO)′	(ΣSiO₂)	1527	1552	1577	1602	1627	1652
5	20	5	2.8	3.5	4.15	4.75	5.2	5.7	15	20	5	4.95	6.2	7.75	9.25	10.8	12.85
	30		2.4	3.15	3.75	4.45	5.0	5.55		30		4.15	5.35	6.75	8.15	9.8	11.7
	40		2.25	2.85	3.45	4.15	4.75	5.35		40		3.65	4.75	6.05	7.45	9.0	10.9
	50		2.05	2.7	3.3	3.95	4.5	5.2		50		3.25	4.4	5.55	6.9	8.5	10.35
5	25	10	2.8	3.35	4.0	4.6	5.15	5.7	15	25	10	4.8	6.1	7.4	8.85	10.4	12.2
	35		2.4	3.00	3.6	4.35	4.9	5.55		35		4.1	5.15	6.55	7.95	9.45	11.45
	45		2.2	2.8	3.5	4.1	4.65	5.3		45		3.6	4.7	5.95	7.35	8.85	10.75
5	20	15	2.95	3.65	4.25	4.85	5.3	5.8	15	20	15	5.6	6.85	8.2	9.65	11.1	12.9
	30		2.65	3.25	3.85	4.5	5.1	5.6		30		4.55	5.8	7.2	8.6	10.0	11.85
	40		2.3	2.95	3.6	4.25	4.75	5.4		40		4.0	5.1	6.45	7.9	9.25	11.2
	50		2.2	2.8	3.4	4.1	4.65	5.3		50		3.55	4.6	5.9	7.2	8.7	10.6
5	25	20	2.9	3.55	4.1	4.75	5.2	5.7	15	25	20	5.25	6.5	7.85	9.2	10.6	12.3
	35		2.6	3.2	3.85	4.5	5.0	5.5		35		4.4	5.5	6.95	8.3	9.7	11.6
	45		2.3	2.9	3.5	4.15	4.75	5.35		45		3.85	4.95	6.3	7.7	9.1	11.0
5	20	25	3.2	3.85	4.45	4.9	5.4	5.85	15	20	25	6.3	7.4	8.55	9.9	11.2	13.0
	30		2.75	3.55	4.05	4.65	5.15	5.6		30		4.75	6.1	7.5	8.75	10.2	12.1
	40		2.5	3.15	3.75	4.4	4.9	5.45		40		4.2	5.4	6.75	8.2	9.5	11.3
	50		2.25	2.8	3.5	4.15	4.6	5.25		50		3.7	4.85	6.1	7.45	8.95	10.7
10	25	5	3.6	4.65	5.8	6.9	8.1	9.4	20	25	5	5.35	6.75	8.4	10.1	12.2	14.7
	35		3.2	4.15	5.2	6.3	7.45	8.9		35		4.5	5.8	7.4	9.05	10.9	13.3
	45		2.9	3.8	4.75	5.85	7.0	8.05		45		4.0	5.2	6.7	8.15	10.0	12.4
10	20	10	4.25	5.25	6.35	7.4	8.55	9.75	20	20	10	6.6	8.0	9.6	11.25	13.2	15.6
	30		3.55	4.55	5.55	6.7	7.85	9.15		30		5.1	6.7	8.1	9.9	11.7	14.1
	40		3.15	4.1	5.15	6.15	7.35	8.7		40		4.4	5.65	7.25	8.85	10.6	13.05
	50		2.9	3.75	4.75	5.8	6.9	8.2		50		3.95	5.15	6.55	8.2	9.9	12.2
10	25	15	4.0	5.0	6.1	7.15	8.25	9.5	20	25	15	5.9	7.45	9.05	10.7	12.5	14.8
	35		3.4	4.5	5.45	6.55	7.7	9.0		35		4.9	6.2	7.9	9.45	11.3	13.6
	45		3.15	4.0	5.05	6.1	7.2	8.5		45		4.25	5.5	7.15	8.7	10.5	12.75
10	20	20	4.6	5.55	6.6	7.6	8.6	9.85	20	20	20	7.45	8.75	10.0	11.7	13.35	15.7
	30		3.85	4.85	5.95	6.95	8.0	9.25		30		5.6	7.05	8.7	10.2	11.95	14.25
	40		3.35	4.3	5.3	6.45	7.45	8.8		40		4.7	6.05	7.65	9.25	11.0	13.2
	50		3.0	4.0	4.95	6.1	7.1	8.4		50		4.2	5.5	7.0	8.6	10.3	12.5
10	25	25	4.25	5.3	6.35	7.35	8.35	9.5	20	25	25	6.7	8.05	9.6	11.05	12.7	15.0
	35		3.6	4.7	5.65	6.45	7.8	9.05		35		5.3	6.75	8.3	9.9	11.6	13.8
	45		3.3	4.2	5.3	6.15	7.35	8.7		45		4.55	5.9	7.45	9.05	10.7	13.0

burization from the time-concentration curve of carbon. It would be necessary to carry out a series of further experiments with a view to more accurately grasp the speed of decarburization. Another important factor in this connection is probably due to the fact that the viscosity of the slag, which depends upon the composition and temperature of the slag in some involved manner, exerts a certain influence upon the formation of the "bumper layer."

The problem of the speed of combustion of carbon has been investigated chiefly by A. L. Feild[2] and M. de Loisy[6] who endeavored to derive numerical relations for the phenomena of diffusion and for the kinetics of the chemical phenomena by means of differential equations. As has also been shown by M. Piérard[7] in his criticisms of Feild's first paper, the exact application of theoretical representations results in practically insoluble functions if the involved relation between the constant of concentration (FeO) and the slag composition and temperature are neglected. Another difficulty is caused by the fact that owing to the boiling of metal and slag, a free diffusion required for the application of the law of diffusion is absent. These considerations and the uncertainty as to the evaluation of the carbon monoxide which may perhaps be variable during the process, conspire to move a satisfactory solution of the problem of the speed of reaction to a considerable distance.

It is noteworthy, however, that the calculation of the concentration of free ferrous oxide in accordance with the series of equations mentioned above, which already proved its value in connection with manganese and phosphorus reactions, also leads to satisfactory relations when applied to the carbon reactions. If it is noted that the experimental data for the 20-ton heats and the 60-ton heats nearly coincide, it will easily be possible to view in Fig. 6 a generally applicable representation of the relations which predominate in ordinary melting practice.

The fact that the calculated value for the concentration (FeO) apparently satisfactorily describes the process of chemical reactions of three different *concomitants* of iron justifies the assumption that the results of the above methods of calculation very closely correspond to the actual facts. For this reason the calculated concentrations of free ferrous oxide were used as a basis in Table I for a series of temperatures and concentration of (ΣFe), (ΣSiO₂) and (ΣCaO)′.

In a prior paper[3] attention has been called to the fact that the concentration constant (FeO) is to assume a controlling importance from the standpoint of the quality of the metallic product, since ferrous oxide dissolves in steel so long as the relation FeO $L\xi$ (FeO), which relation is derived from the Nernst law of distribution, is satisfied.

It is therefore desirable to carefully avoid any incidents or accidents of melting practice which might tend to increase the concentration of the free ferrous oxide of the slag over the amount required for the attainment of the required carbon content.

Stated in the sense of Fig. 6, the shifting into the field located to the right of the dotted line of averages should be avoided toward the end of the process.

Conditions which would tend to shift the condition of the heat into the right hand field are for instance such as the following:

The addition of ore;

The increase of the temperature beyond the range required for proper casting (increase of (FeO) owing to increased dissociation of the lime ferrite);

The increase of the concentration of the silica (ΣSiO₂) in the slag (decomposition of the lime ferrite with formation of lime silicate).

Résumé

Investigations were made as to an inference derived from theory to the effect that the carbon content of the metal must of necessity bear a relation to the concentration of the free ferrous oxide (FeO); the various conceptions as to the constant (FeO) were discussed. It is only possible to ascertain a relation between carbon content and ferrous oxide concentration, if part of the iron contained in the slag is considered as being combined in the form of lime ferrite. The formulae, derived in an earlier report for the mass action of the free ferrous oxide held in the same manner for the carbon reaction in 20- and 60-ton open hearth furnaces; it is probable, that it can be used to judge the operation of the heat for the quality of the steel.

References

[1] *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 73, 1926, page 1079; *Mining & Metallurgical Investigations Bulletin* No. 34.

[2] "Physico-Chemical Phenomena from Melt to Ingot," *Transactions Faraday Society*, Vol. 21, 1925, pages 255–267; *Stahl und Eisen*, Vol. 48, 1928, pages 1341–1344.

[3] "Bericht Nr. 179 des Stahlwerksausschusses des Vereins deutscher Eisenhüttenleute," *Archiv für das Eisenhüttenwesen*, Vol. 3, 1929–30, pages 505–530.

[4] The value ξ has been introduced here to indicate that the equation does not relate to the true condition of equilibrium, for which condition the constants K and K′ apply, respectively.

[5] No illusion should be harbored in connection with the excellent accuracy with which the curves of Figs. 7a to 7d appear to be indicated by the experimental data. In view of the fact that the constants of concentration (FeO) do not considerably vary in one and the same temperature range, the curves also represent approximately the relation between $\frac{\text{constant}}{[\Sigma C]}$ and [ΣC], which of necessity leads to pure hyperbolas.

[6] *Revue de Metallurgie*, Vol. 23, 1926, page 369.

[7] *Revue de Metallurgie*, Vol. 24, 1927, page 47.

Manganese and Its Alloys

By R. Cazaud

(*Translated by special arrangement from Aciers Speciaux, Metaux et Alliages, June 1930, pages 271–278.*)

Manganese plays an important part in the metallurgy of iron and steel. It is an indispensable ingredient on account of its desulphurizing action during the manufacture of pig iron in the blast furnace. It is also an essential deoxidizing agent in the manufacture of steel in the converter, in the open hearth furnace and in the electric furnace. It is added to the molten steel in the form of ferro-manganese (75–80% Mn), silico-manganese (20–25% Si), or spiegeleisen (10–12% Mn).

Manganese is a component element of most steels up to contents of 0.80% in ordinary structural steels, 1–2% in certain special steels and 11–14% in the so-called Hadfield steels. Manganese is also alloyed with copper and aluminum in duralumin, for instance, and with magnesium in "electron" metal.

Pure Manganese

The usual method of preparing pure manganese is the Goldschmidt alumino-thermic method in which manganese oxide is reduced by granulated aluminum. The oxide Mn_3O_4 has a better yield than the oxide MnO_2. M. Gayler[1] has obtained 99.99% pure manganese by distilling commercial manganese in a vacuum high frequency induction furnace. Manganese distils very easily above its melting point which is at 1240° C. The crucible in which it is melted should consist of, or be lined with, alumina or magnesia, refractory materials containing silicon being rapidly destroyed. Manganese obtained under these conditions contains only from 0.002–0.05% Si and 0.02–0.08% Al.

Commercial manganese is a dark gray, hard and brittle metal. However, when alloyed with 3% of copper, manganese prepared by the alumino-thermic method may be drawn into wire.

Manganese Steels

The general constitution of manganese steels has been investigated by Osmond, Dumas, Déjean, Hadfield and Guillet.

Osmond has shown that manganese lowers the critical points of iron. He has also plotted the transformation curve during heating of the manganese steels. It is shown continuous in Fig. 1. Déjean, on the other hand, has found that there are extremely pronounced discontinuities in the curve of the lowering of the transformation points during cooling; see Fig. 2. In accordance with the investigations of Guillet which comprised two series of steels, one containing 0.2% carbon and the other containing 0.8% carbon and of different manganese contents, it is possible to distinguish three classes of manganese steel.

		.02% C	.08% C
1st Class	Pearlite	0–5% Mn	0–3% Mn
2nd Class	Martensite or Troostite	5–12% Mn	3-7% Mn
3rd Class	Austenite	Over 12% Mn	Over 7% Mn

The steels of the first class have the same structure as ordinary carbon steel, the pearlite being more finely divided.

The steels of the second class have a martensitic structure like quenched carbon steels.

Steels of the third class have the characteristic gamma iron or austenitic structure.

The diagram of Fig. 3 indicates the constitution of manganese steels according to their manganese and carbon contents.

Steels of Low Manganese Content

All ordinary and special steels usually contain about 0.2–0.8% manganese. The manganese is present in these steels in the dissolved condition in the ferrite and as a sulphide. It gives the steels a fine pearlitic structure. Certain steels, such as rail steels which contain from 0.6–0.8% manganese, have a partly sorbitic structure. A medium hard steel containing about 1.2–1.5% manganese is of current use. Its manufacture in the basic open hearth furnace and in the electric furnace has been studied in detail in a recent article by E. Decherf.[2] This steel is more susceptible to improvement by heat treatment than ordinary medium hard carbon-steel and when annealed has a maximum tensile strength of about 60 kg./mm.^{2} (85,200 lbs./in.^{2}). When alloyed with about 0.20% nickel this

[1] Marie L. V. Gayler, "Preparation of Pure Manganese," *Journal of the Iron & Steel Institute*, Vol. 115, Part I (1927), pages 393–411.

[2] E. Decherf, *Aciers Speciaux, Metaux et Alliages*, Feb. 1930, page 51.

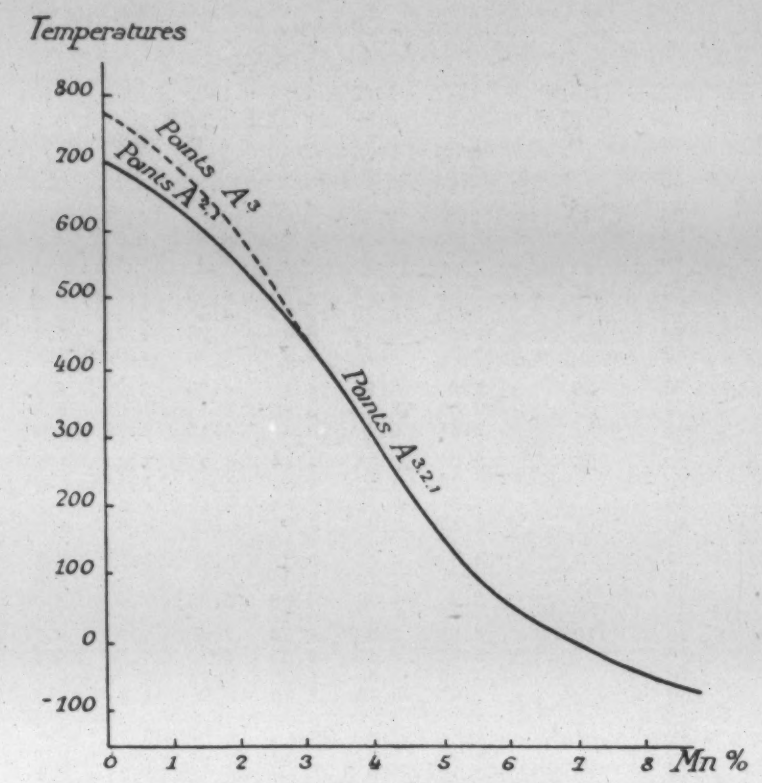


Fig. 1—Transformation Points in Manganese Steels. (Osmond)

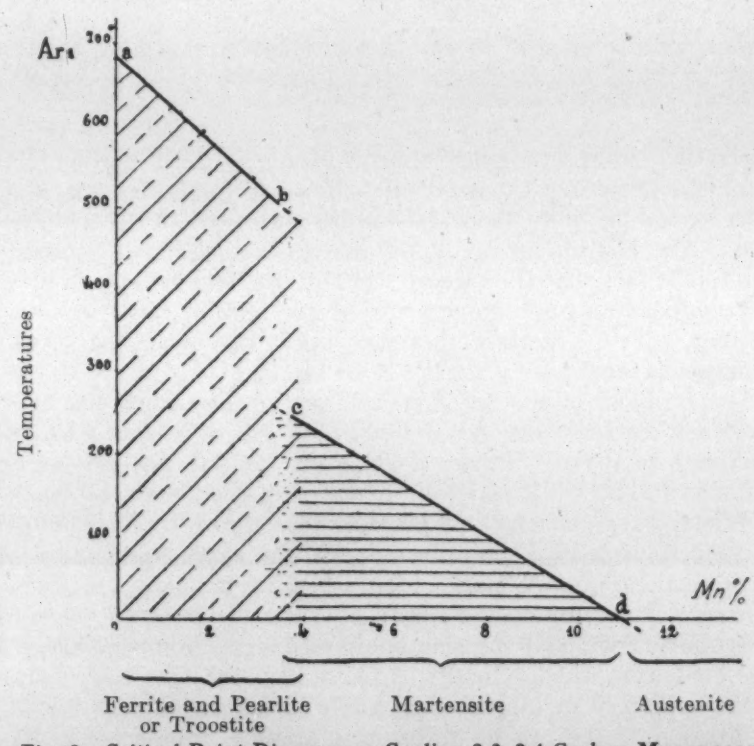


Fig. 2—Critical Point Diagram on Cooling 0.3–0.4 Carbon Manganese Steel

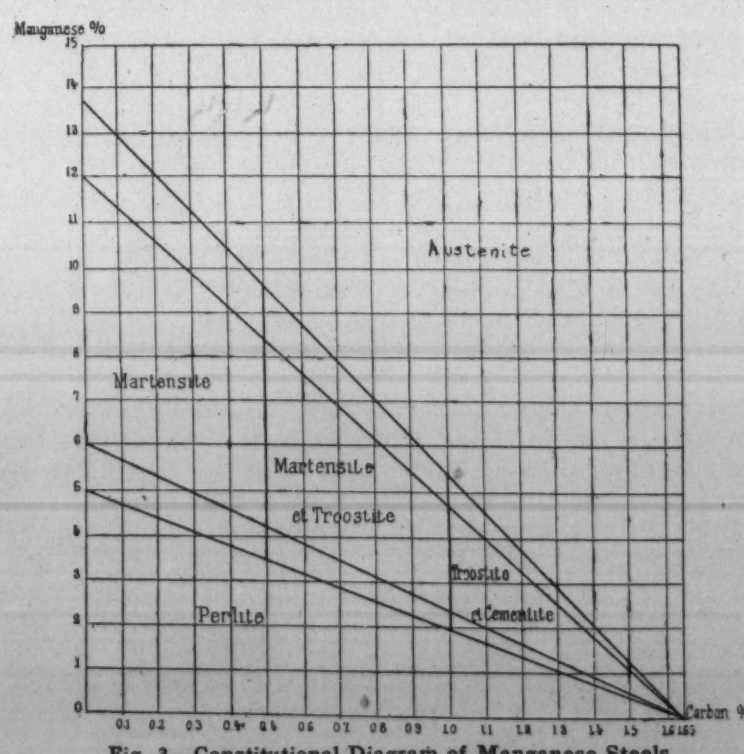


Fig. 3—Constitutional Diagram of Manganese Steels

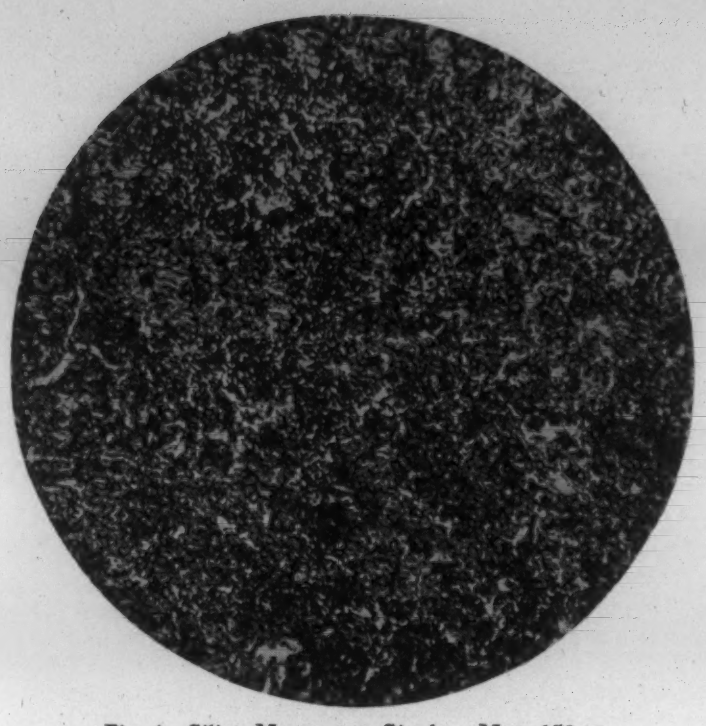


Fig. 4—Silico-Manganese Steels. Mag. 150 ×

steel is very suitable for casting heavy pieces, such as motorbus wheels. After being quenched in water at 925° C. and drawn at 600–650° C. this steel has a maximum tensile strength of 75 kg./mm.² (106,500 lbs./in.²) and an elongation of 18%. This same type of steel when alloyed with 1–2% nickel gives an excellent cast steel.

Silico-Manganese Steels

A steel containing about 0.40% C, 0.70% Mn, 1.6% Si is called silico-manganese steel and used in automotive construction for springs and other parts requiring a high elasticity such as axles and crank shafts. When annealed this steel has a maximum tensile strength of 80 kg./mm.² (113,600 lbs./in.²) and an elongation of 16%. Quenched, it has a maximum tensile strength of 120 kg./mm.² (170,400 lbs./in.²) and an elongation of 8%. It is usually employed after being quenched in water at 850° C. and drawn to 500° C. When used for springs its carbon content should be between 0.4 and 0.6%. Below 0.4% carbon it does not harden sufficiently; above 0.6% carbon its resilience is almost zero. The micrograph (Fig. 4) shows the structure of such a steel. It consists of ferrite (white) and osmondite (dark).

Hadfield Steel

This steel has a manganese content of about 14%. It was first produced by Sir Robert Hadfield in 1880. It has an austenitic structure and its composition is usually within the following limits: Mn: 11.5–14%, C: 1.10–1.40%, Si: about 0.30%. This steel is characterized by the following properties:

1. High elongation;
2. A low Brinell hardness;
3. A high impact resistance; and
4. A great wear resistance.

The first three properties are caused by the austenitic character of its structure which is a solid solution of carbon and manganese in gamma iron. It has a relatively low elastic limit, about 30–35 kg./mm.² (42,600–49,700 lbs./in.²) and a considerable elongation, about 50%, which is uniformly distributed over the whole length of the test specimen. Its maximum tensile strength is 95–100 kg./mm.² (134,900–142,000 lbs./in.²). Particularly noteworthy is its high resilience which is at least 30 kg.-m. (220 ft.-lbs.) Its high resistance to wear is due to a peculiar phenomenon of surface cold working. This is clearly shown by the Shore scleroscope hardness test the first rebound of which gives a Shore hardness of 40; the second rebound gives a hardness of 55, the third of 60 and so on up to a maximum value of about 75 after about a dozen rebounds. This important increase of the hardness under the influence of cold working appears to be due to a transformation of the austenite into martensite. This transformation is also accompanied by a change in the magnetic properties. The 13% manganese steel which is normally non-magnetic becomes slightly magnetic as an effect of the cold working. The austenitic structure of this type of manganese steel may be stabilized by a heat treatment at 1000° C. followed by quenching in cold water. This heat treatment if followed by cooling in air or by quenching in water from a temperature of 900° C. gives a Brinell hardness of 250 to 300 but a lower resiliency.

The transformations which take place during the heating of manganese steel are accompanied by profound changes in the physical and mechanical properties. After drawing at 600° C. the steel becomes magnetic and its electrical resistivity decreases from 70 to 60 microhm-centimeters. The Brinell hardness increases from 200 to 500 and the resiliency decreases from 30 kg.-m. to 1 kg.-m. (220 ft.-lbs. to 7 ft.-lbs.). However, by this treatment the steel is rendered easier to machine.

Manufacture of the 13% Manganese Steel[3]

In the beginning, this type of steel was manufactured exclusively in the crucible furnace which method produced a good quality steel but at a high price. To-day most of this steel is manufactured in the electric and open hearth furnace. At the temperature of molten steel, chromium is capable of reducing iron oxides. It may be added, as ferro-chrome, any time during melting in the electric furnace, but in the open hearth furnace the practice has been to add just long enough before casting to enable it to be melted and become well mixed throughout the charge, care being taken that the slag is not in a strongly oxidizing condition.

Use of Hadfield Steel

Hadfield steel is used whenever hardness and resistance to wear and to impact are desired, for example in the form of castings; for frogs, switches, machinery for crushing hard ores, etc., in the form of rolled or forged pieces; for rails, track bolts, plates for the manufacture of safes, armor plate, etc.

Manganese in Copper Alloys

Alloys of copper and manganese up to about 30% manganese are easily prepared in any type of furnace. However, the presence of carbon is to be avoided because it exerts a hardening effect owing to the formation of a manganese carbide.

Fig. 5 shows a thermal diagram of the copper-manganese alloys which are seen to be a continuous solid solution. The solidus and liquidus curves have a common minimum at 865° C. for 30% manganese. This alloy with a low melting point is commonly used as an addition alloy for adding manganese to other copper alloys. An alloy containing 70% copper, 30%

[3] M. Guedras, L'acier à haute tension au manganese. *Aciers Speciaux, Metaux et Alliages*, July 1929, page 332.

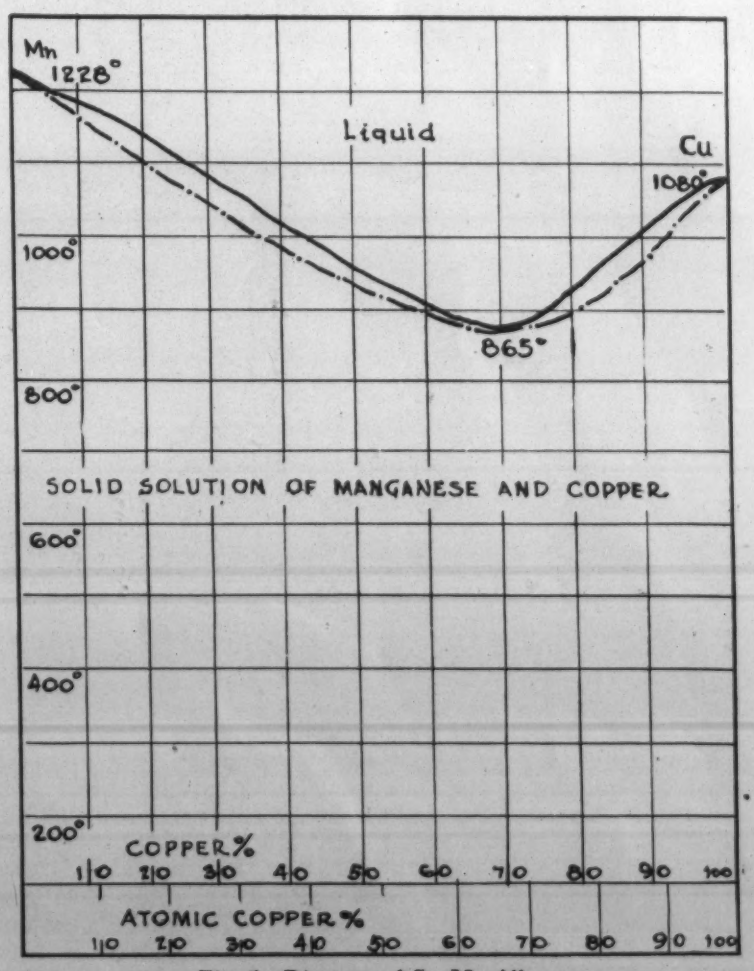


Fig. 5—Diagram of Cu-Mn Alloys

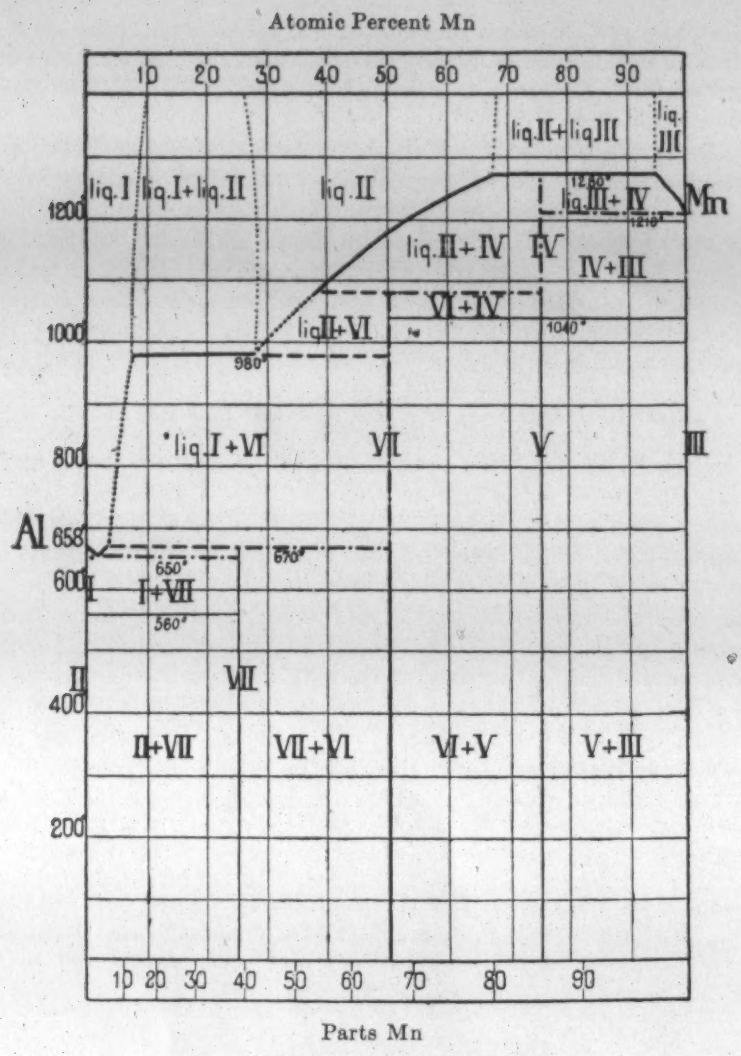


Fig. 6—Diagram of Al-Mn Alloys

manganese and ½–1% iron is used for electric resistance elements. The same use is made of an alloy containing 70–85% copper, 12–25% manganese and 2–5% nickel, called "manganin" which has an electrical resistivity of 42–48 microhms-centimeters and a temperature coefficient of 0.00001. An alloy containing 48% copper, 10% manganese and 39% nickel has an electrical resistivity of 70 microhm-centimeters and a temperature coefficient of 0.

Manganese improves the physical properties of bronzes and brasses. Bronzes may contain up to 2% manganese and brasses up to 4%. Copper aluminum alloys may contain up to 5% manganese whereby they are rendered forgeable and hardenable.

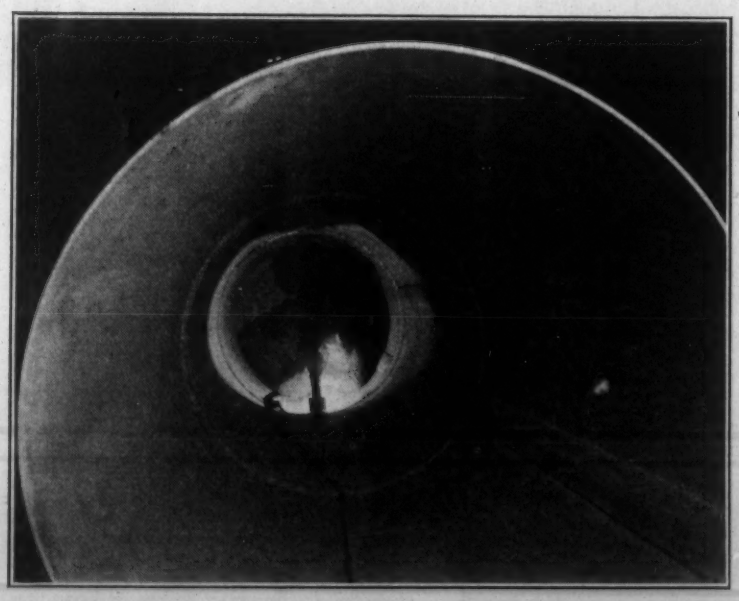
Fig. 7—Alloy of Aluminum with 2% Mn. Mag. 250 ×

According to the researches of E. Morlet[4] the manganese enters into solution in the alpha and gamma phases and does not produce any special constituents.

Manganese in Aluminum Alloys

The constitutional diagram of the alumimum magnanese alloys which is shown in Fig. 6 exhibits two zones of non-miscibility, one between 12 and 40% manganese at 980° C., and the other between 80 and 98% manganese at 1280° C. In the solid state there is practically no solubility of manganese in aluminum. There are three compounds: Al_3Mn, AlMn and $AlMn_3$, corresponding respectively to 38, 67 and 86% manganese by weight. The solubility of Al_3Mn is so small that the alloys containing 2% manganese show the existence of this compound in the form of very characteristic cubic crystals; see Fig. 7. Very few industrial aluminum alloys contain more than 2% manganese. A pronounced effect of manganese in these alloys is to increase the corrosion resistance thereof. It has been found that all aluminum alloys which contain manganese exhibit a greater corrosion resistance than those containing no manganese. It is for the same reason also that amounts up to about ½% of manganese are added to magnesium alloys, as electron alloy for instance.

[4] E. Morlet, *Comptes rendus de l'Academie des Sciences*, July 8, 1929, page 102.



This unusual photograph shows how pressure vessels are fabricated by welding in the plant of the Columbian Steel Tank Company in Kansas City, heavy steel strip plates, called "butt straps" being welded over each welded joint to provide additional joint strength. Tests have shown that by this method of fabrication the joints are in every case stronger than the steel plate itself. Vessels with strength to withstand 1200 pounds pressure per square inch are being built by this system of welding in the Columbian plant.

Steel Founders Adopt Standard Trade Customs

At a general meeting in Cleveland, Ohio, May 14, the Board of Directors of the Steel Founders' Society of America voted its unqualified approval and adoption of a Code of Standard Trade Customs. For months the Society's Industrial Research Committee, headed by Harold S. Falk, The Falk Corporation, Milwaukee, and including Frank D. Glosser, Commercial Steel Casting Company, Marion, Ohio, and Marshall Post, Birdsboro Steel Foundry & Machine Company, Birdsboro, Pa., worked on the project. Questionnaires were circulated, purchasers of steel castings consulted and all existing codes carefully studied.

The new Code, which is given below, clearly sets forth the regulations and conditions under which steel castings are bought and sold. All foundries and their customers will find it easier to transact their business, as there will be complete uniformity in all matters pertaining to the common conditions of sale. All foundries are expected to rigidly adhere to the Code.

The Steel Founders' Society has also developed a Standard Sales Contract. On the reverse side of the contract form are printed the Standard Trade Customs of the industry, which are made a part of the sales agreement.

Standard Trade Customs of the Steel Foundry Industry

A. All quotations are made and all steel castings are sold upon the following terms and conditions:

QUOTATIONS:

B. All requests for quotations shall give actual or estimated

rough weights of the castings, but estimated weights shall not be used as a basis for billing.

C. All quotations on steel castings shall be exclusive of pattern equipment: The latter, if made by the foundry or requiring alterations, shall be an extra or separate charge to the purchaser.

D. Unless otherwise specified, castings are sold as unmachined castings. Terms—Net cash, 30 days from date of invoice. F. O. B. foundry.

E. When the quotations involve the making of piece prices, approximate weights shall be agreed upon and quotations shall be subject to revision on any variation from the original design.

F. Unless specified, any quotation containing more than one class of work, at an average price per pound, is furnished with the understanding that acceptance is for the entire lot, and quotations are good for thirty (30) days only and arrangements for pattern equipment shall be provided for within that time.

PATTERN EQUIPMENT—GENERAL:

G. To eliminate errors patterns should be painted in accordance with the following standard practice:

Surfaces to be left *unfinished* are to be painted *black.*
Surfaces to be *machined* are to be painted *red.*
Seats of and for loose pieces are to be *red stripes on a yellow background.*
Core prints and seats for loose core prints are to be painted *yellow.*
Stop-offs are to be indicated by *diagonal black stripes on a yellow base.*

H. Patterns, coreboxes and loose pieces thereof shall be properly marked for identification.

I. All transportation charges on pattern equipment to and from the foundry shall be paid by the purchaser.

J. All packing and crating cost for transportation of patterns to and from the foundry shall be paid by the purchaser.

RESPONSIBILITY FOR PATTERN EQUIPMENT:

K. Insurance against fire and the elements is the responsibility of the purchaser.

L. The foundry shall be responsible for loss or damage to pattern equipment only when due to careless handling or negligence on the part of the foundry, but not on account of fire or other causes beyond its control.

M. The foundry shall not provide storage space for patterns for which no orders have been received during a period of two years and notification shall be sent to customer for advice as to whether pattern shall be returned or destroyed.

PATTERN EQUIPMENT CHARGES:

N. Subject to purchaser's approval, pattern changes or repairs which become necessary on account of ordinary wear shall be made at the purchaser's expense.

O. When the purchaser furnishes skeleton patterns, coreboxes, sweeps or conjunction patterns which increase the cost of production of castings, an extra charge will be made.

CHANGES, ALTERATIONS AND CANCELLATIONS OF ORDERS:

P. Changes in orders shall be confirmed in writing by the purchaser.

Q. Cancellations of orders must be mutually agreed to by the foundry and the purchaser.

LIABILITY, CLAIMS OF ERROR AND REPLACEMENTS:

R. All agreements are contingent upon fires, strikes, accidents or other causes beyond the foundry's control.

S. To be allowable, claims of error in weight or number of castings shall be made by the purchaser within ten (10) days after receipt of the castings.

T. The foundry shall not be responsible for machine work, labor charges or other expense incurred on castings which are later rejected as defective.

U. Foundry is responsible only to the extent of replacing castings rejected due to defects in workmanship and material, and such castings must be reported or returned to the maker within a reasonable time after shipment.

CONSEQUENTIAL, SPECIAL OR CONTINGENT DAMAGES:

V. The foundry shall not be liable for consequential, special or contingent damages.

SPECIFICATIONS:

W. When chemical specifications, except phosphorus and sulphur, are imposed by the purchaser, the foundry shall not be held on physical tests and vice versa, except by agreement.

ARBITRATION:

X. Any controversy or claim arising out of, or relating to, a contract or the breach thereof shall be settled by arbitration, in accordance with the rules, then obtaining of the American Arbitration Association, and judgment upon the award rendered may be entered in the highest court of the forum, state or federal, having jurisdiction.

COOPERATION:

Y. The foundry or producer will, whenever possible, arrange for the inspection of his plant equipment and product in order to acquaint the purchaser with the foundry problems and to assure him of the desire and advisability of close cooperation between them to the end that a quality product may be furnished and best service rendered to the purchaser.

The value of the new Code and Standard Sales Forms lies in the fact that the conditions of sale are definitely outlined and policies and regulations so clearly set forth that misunderstandings will be avoided.

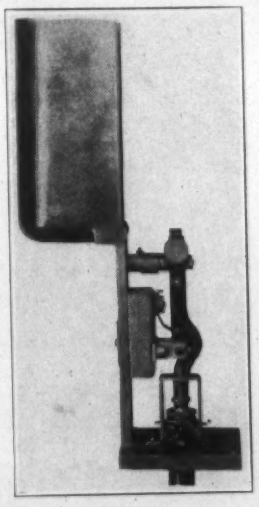
Seventy-fifth Anniversary, Congratulations

To commemorate the seventy-fifth anniversary of the founding of Crane Co., on July 4, 1855, a special issue of "The Valve World" was given over entirely to an account of the celebration.

The whole issue is given over to a visit to Crane Town, a hypothetical city consisting of the various plants of the Crane Co. This city is reproduced in color and shows 600 business buildings of the Crane Co., 100 civic and other buildings and approximately 8000 homes.

This visit permits us to obtain a clear idea as to the vastness of the Crane Co., its manufacturing and storage facilities. This issue of "The Valve World" records the progress in the wide field covered by the facilities, products and activities of the Crane Co.

"The Valve World" is now in its 26th year and has grown from an initial distribution of 50,000 a month to 210,000. The magazine goes to every part of the world. It will be sent free upon request to Crane Co., 836 S. Michigan Ave., Chicago, Ill.



New Thermostat Controls Melting Pots

The General Electric Company announces a quartz rod thermostat for controlling the temperature of soft metal melting pots for use with lead, tin, babbitt, solder, etc. It is an inexpensive device with a high degree of accuracy.

The thermostat consists of an enclosed switch and a nickel-chrome iron tube extending from its base and surrounding a steel piston and quartz rod. The thermostat has a temperature range of 450–950° F. and will control temperatures to within plus or minus 14° F. of its setting. The contacts are designed to carry any current necessary to operate any standard automatic control panel.

Ralph L. Dowdell

Dr. Ralph L. Dowdell, senior metallurgist of the U. S. Bureau of Standards, and formerly Assistant Professor of Metallography at the University of Minnesota, is returning to the University of Minnesota in September as Professor of Metallography, in place of Dr. O. E. Harder who has resigned to go to Battelle Memorial Institute.

Dr. Dowdell and Dr. Harder jointly received the Howe medal of the American Society for Steel Treating in 1928 for their work on austenite. Dr. Dowdell's metallurgical activities have covered a wide range of subjects. He will worthily carry on the high standard of metallographic instruction and research that has been set at Minnesota by Dr. S. L. Hoyt and Dr. Harder.

Callite Products New Handbook

The Callite Products Company, 540—39th Street, Union City, N. J., announce their new catalog and handbook on Tungsten, Molybdenum and Special Alloy products.

This handbook contains useful information on the application of their extensive line of metallugical products for the radio tube, incandescent lamp and electrical industries.

Copies may be procured by engineers and executives writing direct to the Callite Products Company.

Abstracts of Current Metallurgical Literature

These abstracts are not critical, but merely review developments as they are recorded. Beginning with this issue the various classifications are numbered. This number is at the end of each abstract and will be of assistance in mounting them on cards for filing.

DEFECTS (13)

A Microscopic Study of Improperly Heated Forgings. A. S. Jameson. *Transactions American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 81–89.

This paper treats the defects which result from overheating, too rapid heating and underheating for forging, showing how valuable a tool the microscope is in determining occurrence and nature of such defects. WHK(13)

Why Do Intermediate Manganese Steel Rails Fail? H. H. Morgan & J. R. Mooney. *Railway Age*, March 8, 1930, Vol. 88, pages 595–598.

The results of investigations of head failures of manganese steel rails are given. GN(13)

Meeting Problems of Tool Steel Failures. A. H. D'Arcambal. *Iron Age*, Feb. 20, 1930, Vol. 125, pages 583, 622; *Machinery*, April 1930, Vol. 36, page 36.

Abstract of paper read before Cleveland branch of the American Society for Steel Treating. States that carbon, alloy or high speed tool steel has been generally melted in the Heroult furnace and now this is being replaced to some extent by the induction furnace. There are three types of oil hardening tool steels in general use. One contains 0.90% C, 1.75% Mn and has a narrow hardening range. The second has 0.90% C, 1.75% Mn and 0.25% V. The third contains 0.90% C, 1.25% Mn, 0.50% Cr and 0.50% W. High speed steels have 18% W, 1.00–1.25% V, 3.50–4.50% Cr and 0.70% C A lot of cobalt tool steel is being used, the cobalt running 8–10%. Tungsten carbide alloys are still in experimental stage. Progress in chromium plating tools has not been very successful. Rejection of tool steel by customers is due to seams, pipes and improper annealing. Factors that must be controlled in production of cutting tools are: design, quality of steel and hardening treatment. VSP+RHP(13)

Investigations on the Segregation of Metalloids. (Untersuchungen über die Seigerung der Begleitelemente des Eisens.) Christian A. Müller. *Doctor thesis*, Technische Hochschule, Aachen, Germany, 25 pages.

The author discusses the different types of segregation in steel while referring to the literature on the subject. He melted 50 kg. of iron in a high frequency furnace. The ingots (140 mm. square and 350 mm. long) were poured into a mold lined with refractory material in order to prevent the rather small ingots from solidifying too rapidly and to obtain conditions more nearly corresponding to those on large ingots. In the first series the author examined the segregation in steel containing no silicon and only very small amounts of carbon. Sulphur and phosphorus are most strongly segregated. Copper and manganese were found to be almost uniformly distributed. There seems to be a relation between the segregation of copper, manganese and sulphur. The manganese is apparently not only present as MnS but also as MnO. The segregation of oxygen in 7 ingots was determined by the hydrogen reduction method. Usually the oxygen was found to be somewhat higher in the center than in outside parts of the ingots. Special experiments showed a marked influence of phosphorus and sulphur on the results obtained by the hydrogen reduction method. If higher amounts of these elements are present it seems to be impossible to reduce all oxides. It must, therefore, be assumed that the real values for the oxygen content of the center parts of the ingots must be higher. The average segregation for the different elements was found to be: sulphur 60%, phosphorus 35%, oxygen 16%, copper 10% and manganese 7%. These values are expressed as the difference between the values of the center and outside parts of the ingots given as percent of the average content of the whole ingot. Ingots containing no silicon but 0.57–1.04% carbon were examined as to their oxygen segregation by the vacuum fusion method at 1400° C. Oxygen segregates at the same places as the other elements. However, the segregation was found to be more marked than in the first series where the oxygen had been determined by the hydrogen reduction method, again indicating that these results have been influenced by the high phosphorus and sulphur contents. Ingots high in silicon (0.87–1.68) show much less segregation than those low in silicon. This is apparently the result of the killing influence of silicon. The rate of segregation of the various elements increases with increasing oxygen content, i. e., depends on the rate of deoxidation. Investigations on the segregation in 3 different steel ingots taken from 2 open hearth plants showed that the conditions are almost identical to those prevailing in these small ingots. Steel which has been deoxidised with manganese alone shows a much more marked segregation than steel deoxidised with aluminum. Oxygen segregates almost as much as phosphorus. In connection with the rate of segregation of oxygen it may be of interest to note that an investigation has been carried out on the subject at the Eisenhüttenmännisches Institut of the Technische Hochschule, Aachen, Germany. The oxygen was determined by the vacuum fusion method at 1550–1600°. The results obtained with quite a number of samples showed that oxygen segregates as markedly as sulphur. (Diplomarbeit Helmut Pitsch Aachen, 1929.) EHM(13)

MISCELLANEOUS (20)

German Foundry Research Work. E. Piwowarsky. *Foundry Trade Journal*, Nov. 7, 1929, Vol. 41, page 333.

Outlines research work carried out under the author's supervision at the Aachen Technical College. The problems that have been investigated are: growth of cast iron, degasification of cast irons, influence of oxygen, working and behavior of cupola and steel castings. Work on machinability of cast iron is still under investigation. VSP(20)

Efficient Wire Enameling Unit. Christian Rugh, Jr. *Iron Age*, Oct. 24, 1929, Vol. 124, pages 1104–1106.

Gives results of comparative tests of a gas and an electric oven. The varnish considered satisfactory in a gas oven was used for both runs. Comparative production of gas and electric ovens:

Oven	Bare wire Dia. in mils	Insulation Limits in mils	Speed in ft./min.	Fuel consumption per hr.	Fuel cost per hr. in cents
Electric	25.5	1.2–2.1	25	8 kwh.	8.00
Gas	25.5	1.2–2.1	25	160 cu. ft.	12.80

In both cases the number of wires through oven was 48; the number of dips, 4 and the number of heads, 12. The quality of the electric oven product is much improved. Vertical electric tube furnace with an efficient feed mechanism and temperature control was used. VSP(20)

Zinc Plating Aluminum Parts to Prevent Seizing. *American Machinist*, Feb. 27, 1930, Vol. 72, page 363.

The tendency of threaded parts of aluminum and its alloys to seize may be prevented by plating with zinc. The following process has proven satisfactory: dip the object to be plated in a 10% solution of hydrofluoric acid, rinse with water, dip in cold concentrated nitric acid, rinse thoroughly with water, immerse immediately in the plating bath. The bath should be prepared as follows:

	Ounces per Gallon
Zinc cyanide	6
Sodium cyanide	6
Sodium carbonate	6
Sodium fluoride	2
Gum arabic	1/8

The life of the zinc plating may be extended by the application of anti-seize compound. RHP(20)

Industrial Research Should Open Ways to Unlimited Change. Willis R. Whitney. *Iron Trade Review*, Nov. 7, 1929, Vol. 85, pages 1172–1174.

From paper presented at World Engineering Congress in Tokyo, Oct. 1929. See *Metals & Alloys*, Feb. 1930, Vol. 1, pages 370–372. MS(20)

Cobalt-Steel Magnets for Compass Needles. John R. Gier. *Electric Journal*, Apr. 1930, Vol. 27, pages 236–237.

A set of hexagon-grooved rolls were designed to hasten the rolling operation of the cobalt steel and thus diminish the opportunity for loss of carbon from the compass needles. With the modified process the needles were carburized previous to hardening by heating them 12 hours in a carburizing compound at 850° C. The rigorous "bounce test" is applied to insure sufficient immunity to demagnetization. WHB(20)

Advantages of Metal-Clad Switchgear. G. H. Kohn. *General Electric Review*, April 1930, Vol. 33, pages 252–253.

Advantages claimed are: safety, greater service reliability, reduction in field labor, easily removable oil circuit breaker elements, decreased floor space and decreased maintenance expense. Little or no differential in cost is required to justify moderate-capacity metal-clad switchgear. WHB(20)

Metallurgy of Hard-Faced Rotary Bits. W. A. Wissler & C. W. Metzger. Paper at the Fall Meeting, Southwestern district, American Petroleum Institute, Galveston, Texas, Sept. 5–6, 1929. *Oil & Gas Journal*, Sept. 5, 1929, Vol. 28, pages 75–76, 146; *Oil Weekly*, Sept. 6, 1929, Vol. 54, pages 52–56; *Oil Field Engineering*, Oct. 1, 1929, Vol. 6, pages 15–16.

The function of the steel in the body of the bit is discussed, and emphasis is placed upon the proper working and heat treating of such steel. Methods and precautions used in hard-facing are discussed, acetylene welding being preferred. Properties of hard-facing metals are discussed; "red hardness" is illustrated by charts. (20)

The Granulation of Metals. Ernest A. Smith. *Metal Industry*, London, Oct. 25, 1929, Vol. 35, pages 387–390.

Granulation is the act of forming metals into grains or granules by pouring them when melted in a thin stream into water. Different metals have different surface tensions, and shapes assumed by the drops differ according to nature of the metal. Granulation of metals by pouring into water has been used for sometime. Describes bean and feather shot. To secure uniform product the molten metal is often teemed from crucible into a ladle. Conditions to be observed for successful granulation are: (1) Correct pouring temperature. (2) Maintenance of steady stream of metal. (3) Suitable height of ladle above surface of water. (4) Temperature of water. (5) Use of clean water. (6) Drying under conditions that will prevent oxidation or discoloration of metal. VSP(20)

Iron and Steel Melting in the Electric Furnace. Delton T. Waby. *Journal Western Society of Engineers*, June 1929, Vol. 34, pages 339–364.

A discussion of the history of iron and steel melting, types of electric furnaces and of auxiliary equipment, electrodes, etc. Curves show the production of steel in the electric furnace since 1916 and together with the characteristics and operating data on furnaces with basic and with acid linings. Specific data are given for a 3-ton per hour furnace for a 3 1/2-year period and show: 648 net tons/month, 500 kw.-hrs./ton, 5.08 lbs. graphite electrode/ net ton, 5.84 net tons/heat. In the United States 24% of steel castings and 13% of alloy ingots are melted electrically. Statistics are given on foreign operations. WHB(20)

FOUNDRY PRACTICE & APPLIANCES (22)

High Speed in Cupola Melting. W. N. Truxell. *Iron Age*, Dec. 19, 1929, Vol. 124, pages 1659, 1705.

From an address before the Philadelphia Foundrymen's Association, Dec. 11. Discusses the advantages of melting iron at the cupola's rated speed or better. The average cupola operates at approximately 75% of its rated speed. Describes a composite cupola. A composite average of American cupolas will conform to the following description: Height of charging doors from the tuyères is 13–15 ft. Tuyères are single continuous with a height equal to 1/12 of diameter as lined. Average for an economical cupola melting hot iron is a crucible 12 in. high from sand bottom to tuyère. Height of melting zone varies with kind of coke used. Ideal coke for fast melting should contain high total carbon and high percentage of volatile matter. VSP(22)

Coal Dust and Facings in the Foundry. H. Winterton. *Foundry Trade Journal*, Jan. 2, 1930, Vol. 42, pages 4–6.

Paper read before the Sheffield branch of the Institute of British Foundrymen. Gives results of experiments conducted. Red Wolverhampton sand was used. The black sand was ordinary floor sand which contained coal dust in various stages of decomposition. Results showed that gas generated forces itself along face of sand and metal and out the joint. Use of coal dust in proper proportions gives face of casting a good appearance and when not used casting has a harsh and gray appearance. Castings are disfigured by the use of excessive coal dust or coal dust and sand improperly mixed. The function of facing is to prevent molten metal from eating into the mold, and also to form a skin on castings. Points to be considered are nature of mold, class of casting and condition of the various sands. VSP(22)

Monel Metal and Nickel Foundry Practice. E. S. Wheeler. *Fuels & Furnaces*, March 1930, Vol. 8, pages 339–340.

See *Metals & Alloys*, May 1930, page 527. MS(22

Production of Synthetic Gray Iron in the Electric Furnace. (Die Erzeugung von synthetischem Grauguss im Elektroofen.) NATHUSIUS. *Giesserei*, Vol. 16, Oct. 25, 1929, pages 993–1000.

Includes discussion. The production of synthetic cast iron in the electric furnace from charges of steel scrap and petroleum coke. The importance of controlling the carbon content and the production of finely divided graphite for high quality metal is discussed. (22)

Metallurgical Principles Underlying the Production of High-Grade Malleable Castings. (Die metallurgischen Grundlagen zur Erzeugung eines hochwertigen Tempergusses.) R. STOTZ. *Giesserei*, Vol. 16, Sept. 6, 1929, pages 839–845.

The author discusses the metallurgical considerations involved in the production of high quality white heart malleable castings. He quotes the example of the development of black heart castings in America. The main difficulty in melting pig iron for malleable is the prevention or control of oxidation and gas absorption which tends to reduce the ductility on annealing. The behavior of various modern furnaces in this matter is discussed. Recent practice has been to raise the manganese content in German malleable pig from about 0.1% to 0.5–0.6% with beneficial results. This has avoided the necessity of importing English pig iron. Black heart malleable can be cast from the cupola from such high manganese irons. One of the main drawbacks with white heart castings is that different sections require different annealing periods to give proper malleablization. Each 1/4-in. increase of section requires an additional 24 hours at full heat. The author then discusses the theory of annealing as applied to black heart malleable cast iron and outlines possible directions for improved practice in its production. (22)

Cupola Malleable Is Cast in Permanent Molds. HARVEY W. HYDE. *Foundry*, Mar. 1, 1930, Vol. 58, pages 104–106; Mar. 15, 1930, pages 109–112.

Article describing various phases in the development and application of iron molds for cupola malleable practice. Permanent molds are those in in which the entire casting is made against a metal surface. Small pieces may be produced in some cases, but investigation shows malleable iron from a cupola is not adapted for small work nor to automatic machinery. Best results were obtained with castings of large and heavy section. Chill mold provides rapid chilling of metal from exterior, consequently reduces shrinkage. Superior surface is obtained in proper use of chill molds. Chill molds may be made from any gray or malleable iron mixture. Graphite content of metal used for molds is the eventual cause of failure. Mn added to bring content of metal to 0.65–0.75% toughens matrix and assists in resistance of mold cracking. S should be about 0.12% and P about 0.80%. Cast steel as mold material, especially with Ni and Cr addition to produce heat resisting qualities seem satisfactory. Interior of mold should be cast as near to size as possible. Rapid cooling causes severe strain on mold wall and it is apt to split. Describes machines used. Prior to starting work mold should be heated to about 250° F. This prevents condensation of water and consequent explosions. Mold should be maintained at 250–350° F. In setting cores, they must be lined up correctly before closing the mold. If there is a sharp change in contour of casting next to core, the edge of opening should be formed in the core. The reason is, that a strain is set up and a small crack will result. An ideal chill mold is one through which metal enters at the bottom through an external core. Metals for chill mold castings should be poured as cold as possible. The higher the C and Si, and the heavier the section, the colder the metal is poured. Temperature of from 2400–2500° F. was the range most suitable. Metal poured too cold will show wrinkles at bottom of casting. When cupola malleable is cooled to the pouring ranges, metalloids and oxides are thrown out of solution and collect on surface of metal. Semipermanent molds are advantageous in casting heavy sections. VSP(22)

Economy and Efficiency of Electric Furnaces Is Demonstrated in Mine Foundries. W. E. LEWIS. *Engineering & Mining Journal*, Nov. 23, 1929, Vol. 128, pages 820–821.

Repair parts are being made in the electric furnace. Carbon and alloy steel, manganese-steel and gray iron, and abrasion-resisting grinding balls and ball-mill liners of hard white iron are included. Cost figures for a 1-ton operating charge electric furnace making cast iron, and operating cost figures for a 3-months' period making white-iron grinding balls in a 1 1/2-ton per hour furnace are given. WHB(22)

American Brass Foundry Practice. Part 5. Arranging Pouring Position. CHARLES VICKERS. *Foundry*, Feb. 15, 1930, Vol. 58, pages 73–75, 87.

Discusses theories evolved to account for the changes taking place when molten metal or alloy reverts to the solid state and explains them. Defective arrangements of patterns may be responsible for heavy losses of castings due to leaking under pressure, and gives reasons for leaks. Describes French method of pouring bronze valves. Gating is a method that can be relied upon to produce a maximum amount of sound castings. Iron is selected as the one most suitable for refining the grain of aluminum bronze alloys. Iron addition to gun metals, phosphor bronze and the like alloys would not work out satisfactorily for the reason that sufficient iron cannot be added to these alloys. Contains numerous illustrations. VSP(22)

Improved Aluminium Castings. N. C. ASHTON. *Metal Industry*, London, Jan. 31, 1930, Vol. 36, page 151; *Foundry Trade Journal*, Vol. 42, Feb. 6, 1930, pages 101–105, 108; Discussion, Feb. 13, 1930, pages 119–120.

Abstract of paper read before the Institute of British Foundrymen, Jan. 4, 1930. Discusses method of eliminating faults in aluminum alloy casting by using liquid boron-trichloride. Most important result of using boron-trichloride for purifying and grain refining aluminum alloys is that the zinc series, which are very corrosive, can be made highly resistant. Recommends quick melting in carborundum crucibles, which prevent the melt from being gassed, and the undue formation of oxide. VSP(22)

Present-Day Methods in Production and Utilization of Automotive Cast Iron. A. L. BOEGEHOLD. *Preprint for March 1930 Automotive Symposium, American Society for Testing Materials*, 13 pages; *American Metal Market*, Vol. 57, No. 73, April 15, 1930, pages 10, 12; *Fuels & Furnaces*, Vol. 8, April 1930, pages 483–485, 494; *Iron Age*, Vol. 125, March 27, 1930, page 930.

Discusses the importance of molding sand testing and control, of controlling coke quality by observing the burning rate, of control of weight of air admitted to the cupola, of removing excess moisture from the air by refrigeration, use of hot-blast cupolas and briquetting of borings. Different lots of pig iron, all meeting the same specifications, behave differently. Chill bars and transverse bars are cast throughout the day to detect these differences. The coefficient of expansion of cast iron is materially reduced by the addition of 1 1/2% Ni. Useful compositions are:

Iron	Total Carbon, %	Manganese, %	Phosphorus, %	Sulphur, %	Silicon, %	Chromium, %	Nickel, %
Cylinder Iron No. 1	3.15–3.30	0.55–0.75	0.20 max.	0.12 max.	2.00–2.40	0.06–0.16	0.03–0.08
Cylinder Iron No. 2	3.15–3.30	0.55–0.75	0.20 max.	0.12 max.	2.00–2.40	0.05–0.07	0.25–0.35
Cylinder Iron No. 3	3.15–3.50	0.50–0.80	0.20 max.	0.12 max.	1.75–2.25		1.00–1.50
Flywheel Iron	3.10–3.25	0.55–0.75	0.20 max.	0.12 max.	1.85–2.35		
Soft Iron	3.25–3.50	0.55–0.75	0.35 max.	0.12 max.	2.45–2.80		
Permanent Mold Iron	3.45–3.60	0.50–0.70	0.30–0.40	0.10 max.	2.55–2.75		
Piston Ring Iron (Individual Cast)	3.45–3.60	0.60–0.70	0.45–0.55	0.08 max.	2.80–2.90		

HWG & WHB & MS(22)

FURNACES AND FUELS (23)

Calorific Value, Heat Balance and Efficiency in the Heating Practice. (Heizwert, Wärmebilanz und Wirkungsgrad in der Feuerungstechnik.) K. RUMMEL & G. NEUMANN. *Archiv für Eisenhüttenwesen*, Feb. 1930, Vol. 3, pages 531–544.

The article considers the fundamentals of heat balances and gives some examples: the heat balances of a melting furance, a gas producer and an open hearth furnace. GN(23)

The Tangible Advantages of Electric Heat Treatment. WIRT S. SCOTT. *Iron and Steel Engineer*, March 1930, Vol. 7, pages 118–122.

Paper at Electric Heating Conference at Penn State, November 1929. Advantages of electric heating for annealing, hardening and tempering are balanced against the somewhat higher cost than for other forms of heating. WHK(23)

Foundries Use Gas for Annealing. C. B. PHILLIPS. *Iron Age*, Feb. 27, 1930, Vol. 125, pages 637–639, 692; *American Gas Association Monthly*, Vol. 12, March 1930, pages 104–106, 138.

Discusses the gas-fired car bottom type of annealing furnace employed by the Link Belt Co., Chicago. Economies effected included: A decreased cost for fuel; shorter heating up and holding periods; more uniform heat distribution; exact atmospheric control; and the production of proper furnace pressure and maintaining it automatically. Compares the cost of using oil, electricity and gas for annealing. VSP(23)

A New Induction Furnace for Metals. E. FR. RUSS. *Brass World*, March 1930, Vol. 26, pages 59–61.

An illustrated description of an electric furnace suitable for the melting of all copper alloys without introduction of constructive modifications. The important feature of the "Russ" furnace is that the metal being smelted is excited by induction currents and that the part of the furnace enclosed by the transformer (annular groove) has a smaller cross-section than the hearth chamber. WHB(23)

Electrical Furnaces with Controllable Atmospheres. C. L. HEISLER, JR. *Industrial Engineering*, March 1930, Vol. 88, pages 136–138.

Stating that electric furnaces are particularly well adapted to atmospheric control; control of normal atmospheres, neutral atmospheres, and reducing atmospheres is especially considered. GN(23)

Investigation of Various Influences in Open Hearth Practice by Large-Scale Research. (Untersuchung verschiedener Einflüsse in Siemens-Martin-Ofenbetrieb durch Grosszahl-Forschung.) ALBERT HERBERHOLZ. *Archiv für Eisenhüttenwesen*, Sept. 1929, Vol. 3, pages 173–184.

The effect of furnace rebuilding, furnace age, charging time, gas heating values and C. content of the tapped melts on the specific heat-consumption (I) and the furnace output is investigated on a plant scale. No great difference in specific heat consumption or in the output is found before and after the rebuilding. With increasing furnace age the output decreases uniformly, and specific heat consumption increases correspondingly. The increase of the latter may be represented by (1) $Z = 0.1\,n$ (for C contents below 0.1%) and (2) $Z_1 = 0.08n$ (for C contents above 0.1%), Z and Z_1 being specific heat consumption and n the furnace age (or heat no.). That the specific heat consumption is higher at lower gas heating values is partially explained by the lowering of the flame temperatures with decreasing heat values. Higher heat expenditure is necessary for C contents below 0.1% C than for those over this, the differences between the 2 increasing with increase in furnace age (not linearly) and being greater at the lower heating values. A lessening of the charging time causes a decrease in the specific heat consumption. Graphs illustrating these relations are given. (23)

Electric Heat-Treating Furnaces. A. H. VAUGHAN. *Iron Age*, Jan. 30, 1930, Vol. 125, pages 357–361.

Abstract of paper read before the Cleveland chapter of the American Society for Steel Treating. Early electric furnace design was confined to box and car types. There are many points of inferiority in the batch type furnace. One of these is the difficulty of attaining a satisfactory heating speed, while in the continuous furnace every zone continually does the same part of the heating and can operate close to 100% capacity. Furnaces of 1000 and 3000 kw. have been built. In annealing work the counter-flow recuperative type of furnaces have been used. Furnaces for the heat treatment of finished parts are usually small, mostly under 75 kw. per chamber Conveyor type of furnaces are difficult to build. With few exceptions the continuous process does not fit well in the steel industry. Heat treatment of aluminum alloys is an example of a process where electric heat is the only solution. For this purpose the round pit furnaces, 5 or 6 ft. in diameter and 3 to 12 ft. deep are used. The largest furnace now in use is rated at 3000 kw. VSP(23)

Annealing Stampings in Automatic Furnace. W. M. HEPBURN. *Machinery*, March 1930, Vol. 36, pages 530–531.

Describes the construction and arrangement of the drying tanks, the wash tubs, and the furnaces, used by the Mullins Mfg. Co. of Salem, Ohio, for the annealing of drawn sheet metal. Automatic operation is used throughout the plant. RHP(23)

Electric Salt Bath Furnaces for Heat Treating. A. E. BELLIS. *Iron & Steel Engineer*, March 1930, Vol. 7, pages 141–147.

A liquid medium offers 3 combined advantages of: (1) uniform heating; (2) perfectly preserved surface, and (3) controlled rate of heating. Adaption of a Lavite heating bath and a Lavite cooling bath, both of which can be controlled to give the best rates of heating and cooling, it is possible to avoid surface injury to develop remarkable performance properties in high-speed steel, and to eliminate the distortion troubles that have heretofore limited its application to fine tools. In the new type of salt bath furnace an electrode is immersed in the bath, and the current passed from it to the pot wall. The heat is generated within the bath, and no part of the furnace or bath is overheated. The salt employed is an insulator when solid, so must be melted initially by some other means. Several arrangements for doing this have been developed—one an arc method. The electrode is adjustable making the power drawn flexible. A special alloy with special electric and oxidation-resisting characteristics insured almost indefinite electrode life. Heat efficiency is over 90%. The possible pot size is unlimited and the limit of capacity of heat input is only that of the heat conductivity of the metal involved. These considerations insure the possibility of getting high temperatures with speed and control, and the possibility of very rapid quantity production without over-heating the metal being treated. Discussion included. WHB & WHK (23)

Selecting Heat for Heat Treating. ROBERT M. KEENEY. *American Machinist*, Jan. 30, 1930, Vol. 72, pages 225–227.

See *Metals & Alloys*, April 1930, Vol. 1, page 478. RHP(23)

Open-hearth Men Seek Better Gas Control and Larger Furnaces. *Iron Trade Review*, Jan. 2, 1930, Vol. 86, page 21.
Gives opinions of several authorities on trends in open-hearth furnaces. MS(23)

Electric Arc-furnace Regulation. *Electrical Review*, Mar. 14, 1930, Vol. 106, pages 513–514.
Describes the automatic electrode control equipment of Ateliers H. Cuénod, S. A., Geneva. The movements of the electrode are made by means of a hydraulic ram, operated by an oil governor, which in turn is controlled by a solenoid energized by the current taken by the furnace. The regulator can be utilized for regulation of current, voltage, power, impedance, or for any combination of them. MS(23)

The Importance of the Brackelsberg Furnace for the Iron Foundry. P. Bardenheuer. *Foundry Trade Journal*, Sept. 12, 1929, Vol. 41, pages 191–193; Sept. 19, 1929, pages 210–211.
Abridged translation from Die Giesserei, Nov. 23, 1928. Discusses the application of the furnace to the production of high-grade gray-iron castings. An essential feature is that coal dust flame enters furnace directly and without affecting the melt. Gas absorption is minimized. The process differs widely from the cupola practice. This method of melting gives sound castings throughout. Iron alloys melted in the Brackelsberg furnace are free from gases and oxides. Castings with 28-ton-tensile strength have been obtained. Describes the application of the furnace to melting malleable iron, the reduction of piping, melting costs and high elongation. VSP(23)

The Calculations of Electric Furnaces and Kelvin Effect. (Le calcul des fours electriques et l'effet Kelvin.) Albert Levasseur. *Journal du Four Electrique*, Feb. 1930, Vol. 39, pages 53–54.
A method proposed for accounting for skin effect in the design of electric furnaces. JDG(23)

Induction Furnaces. *Engineer*, Dec. 20, 1929, Vol. 148, pages 652–654; Dec. 27, 1929, pages 680–682.
The Ajax-Northrup, the Ajax-Wyatt and the Metrovick furnaces are described. The first two are especially suited to handling non-ferrous metals having high melting points. The Metrovick, with automatic temperature control, is commonly used for special steels. Examples of furnaces and auxiliary equipment are illustrated. (23)

Electric Furnace Found Ideal for High-Grade Steel Castings. D. Zuege. *Electrical World*, Nov. 2, 1929, Vol. 94, pages 880–882.
The equipment of the Sivyer Steel Casting Co., Milwaukee, Wis., consists of two Moore 'Lectromelt furnaces, and a Hevi-Duty electric furnace for annealing. The melting furnaces have capacities of 3-tons and 1/2-ton, respectively. The annealing furnace consists of a heating chamber and a variable-rate cooling chamber. The furnace can take 2 trays of castings, each 1.4 m. × 1.7 m. and about 1 meter high, the charge weighing 5–8 tons depending upon the shape of the castings. Power consumption varies between 230 and 300 kw.-hrs./net ton of castings. Car movements are electrically controlled and the average performance is 625 kw.-hrs./ton. High-grade castings are obtained. The type of annealing furnace used insures uniformity of temperature and excellent control. WHB(23)

Melting Iron in the Rotary Furnace. (La fusion de la fonte au four rotatif.) Ch. Bouvard. *Fonderie Moderne*, Dec, 10, 1929, Vol. 23, pages 575-580; *Foundry Trade Journal*, Jan. 23, 1930, Vol. 42, pages 63–64.
Rotary furnace used for the manufacture of malleable cast iron can be used for melting cast irons of all classes and also steel castings. This furnace has superseded the open-hearth furnace for high grade malleable. It attains very high temperatures without oxidation of the metal; produces finished iron differing very little from constituents of charge; possible reduction of carbon content due to high temperature without alteration of other elements; protection of bath from products of combustion; rapidity of melting and pouring; and low consumption of fuels. VSP(23)

Thirteen Classes of Mechanisms Convey Metal Through a Furnace. E. G. de Coriolis. *Iron Age*, Oct. 10, 1929, Vol. 124, pages 960–962.
Read before the American Society of Mechanical Engineers. Classifies and describes mechanisms for conveying metals through heat treating furnaces. They are: Pusher, puller, car bottom, conveyor chain and belt, rotary heart, cylinder and retort, spiral, shaker, vibrator, walking beam and roller hearth. VSP(23)

Furnace Cooled by Double Auxiliary. R. E. Cox. *Iron Age*, Nov. 14, 1929, Vol. 124, pages 1311–1312.
Describes annealing furnace having variable but controllable heating and cooling cycles. The design embodies the following features: 1. Even and efficient heating at regulated rate. 2. Cooling periods either short or long controlled. 3. Fast cooling without honeycomb wall construction, and without air in contact with work, eliminating oxidation and decarburization. 4. First grade products and unusual economies per ton of material. VSP(23)

Electric Bearing Metal Furnace and Baths. (Elektrische Lagermetall-Schmelzöfen und Schmelzbäder.) *AEG Mitteilungen*, Jan. 1930, pages 64–66.
Electric furnaces for melting bearing metals, tin and lead, tilting and stationary are described. Also salt pots and oil baths. They can be furnished with automatic temperature control. CEM(23)

Fuel Control in Iron and Steel Practice. Edgar C. Evans. *Proceedings Staffordshire Iron & Steel Institute*, Session 1928–29, Vol. 44, pages 68–82.
Includes discussion. Compares fuel efficiency under different conditions of practice in British and Continental plants. Gives a curve prepared according to system elaborated by Mr. H. C. Armstrong, which plots fuel consumption per hour against amount of stock per hour. Uses similar method for blast-furnace investigation where iron and slag are both to be considered and develops an equation. Equation is used as basis for examination of various operating furnaces to analyze factors involved in blast-furnace efficiency. To measure fuel consumption minute by minute, volume of air blown is measured which is proportional to the coke consumed. Recommends measurement and utilization of blast-furnace gas in blast-furnace stoves, boilers, soaking pits, reheating furnaces, etc. Compares fuel problem for open-hearth furnaces of Continental and British plants. Constancy of gas pressure and constancy of air supply to furnaces is important in both open-hearth and mill practice. Use of curve plotting fuel burnt against output per hour will give valuable guide to efficiency of methods used. Accurate knowledge of steam supply in various units is important. LFM(23)

Electric Furnace Developments. D. F. Campbell. *Proceedings Staffordshire Iron & Steel Institute*, Session 1928–29, Vol. 44, pages 33–51.
Includes discussion. Reviews briefly the history of the electric furnace. Describes various melting and heat treatment operations to which electricity has been applied and gives some of the factors considered when deciding on use of electricity. Types of furnaces discussed include induction-furnaces of the Ajax Wyatt type for brass, high frequency electric furnace for nickel and nickel alloys, furnaces of granular carbon resistor type for copper and the Arc Furnace for steel. Various types of heat treatment furnaces are discussed, including box type furnaces, continuous strip annealing furnaces, Snead tube annealing machines, side charged electric annealing furnaces, furnaces of the rotating hearth type, three-chamber furnace, and water-sealed furnaces. For temperatures of 1100–1200° C. trouble is experienced in getting resistors capable of giving these temperatures. Recommends use of resistors of graphite, silicon carbide impregnated with silicon, or a mixture of carborundum and silicon. Article deals primarily with use of the electric furnace in non-ferrous metallurgy. LFM(23)

Smelting Secondary Aluminum and Aluminum Alloys. Part 9. Furnaces Used in Melting. Robert J. Anderson. *Metal Industry*, N. Y., Oct. 1929, Vol. 27, pages 469–472.
The choice of furnace to be used is governed by: (1) the class of scrap to be used, (2) volume of production to be turned out and (3) fuel available. The types of furnaces used include the following: pit furnaces, stationary and tilting crucible furnaces, stationary and tilting iron-pot furnaces, open-flame tilting furnaces and stationary and tilting hearth furnaces. Electric furnaces have made little progress in melting aluminum and its alloys either in foundry practice, rolling or secondary smelting. Coke, coal, oil or gas is used as fuel. VSP(23)

Electrical Manufacturers Can Lead by Example. *Electrical World*, Nov. 16, 1929, Vol. 94, pages 990–991.
"Various authorities have estimated that the potential load and energy consumption of industrial applications of electric heat will eventually equal or exceed the corresponding values of the present motor load." Several illustrations are shown of electric furnaces which have proven, by economic studies, to be advantageous. WHB(23)

REFRACTORIES & FURNACE MATERIALS (24)

Silica Refractories. George Knox. *Foundry Trade Journal*, Jan. 2, 1930, Vol. 42, page 13.
Silica bricks when properly manufactured fail very rarely. Tests insure that silica content in raw material is satisfactory, and percentages of impurities low. If silica is high, lime is added to form a bond. In calcining, temperature must be controlled when lighting up and during initial stages. Finishing temperature is about 1550° C. Finished products are tested microscopically to insure conversion of quartz into tridymite and cristobalite. VSP(24)

Cupola Refractories. Colin Presswood. *Foundry Trade Journal* Nov. 21, 1929, Vol. 41, pages 369–371, 376; *Metallurgia*, Nov. 1929, Vol. 1, pages 15–16, Dec. 1929, pages 81–82, Jan. 1930, pages 127–128.
Paper read before the London Branch of the Institute of British Foundrymen. Describes various types of refractories used in cupola lining. Cupola linings are subjected to: (1) High temperature; (2) rapidly changing temperature; (3) fluxes; (4) mechanical wear and abrasions. Discusses each. VSP (24)

Silica and Magnesia Bricks. (Les briques en silice et en magnesie.) *Journal du Four Electrique*, Feb. 1930, Vol. 39, page 59.
An abstract from *Technique Moderne*, Sept. 1929. JDG(24)

Silica Refractories for Coke Ovens. Richard Richards. *Proceedings South Wales Institution of Engineers*, Nov. 12, 1929, Vol. 45, pages 419–461.
The high softening point under load possessed by silica refractories places them in a position unapproached even by the best fireclay products. The life of siliceous fireclay refractories in ovens carbonizing very salty coals is uncertain; in extreme cases their renewal may be necessary in under a year, whereas silica refractories are unaffected. Silica bricks have greater heat conductivity than fireclay. On account of their greater mechanical strength, silica walls can be thinner and hence flue temperatures can be lower or carbonization time can be reduced. They are also less liable to spall. Some impurities (<2.5%) are necessary in the raw quartzite to accelerate the conversion of the quartz into its modifications. Mica is particularly deleterious. Cement quartzites are superior to crystalline ones. Coarsely ground material is used for open-hearth bricks. Coke ovens and gas retorts require a finer grained product. The maximum size of particle in a refractory should be 6 mm. and should grade down to not less than 35% of fines (<0.1 mm.). Fines pack pore space and by their small size facilitate conversion of the quartz. Discussion. Feb. 11, 1930, Vol. 45, pages 467–475. AHE(24)

GASES IN METALS (25)

Capacity of Pure Iron and Some of Its Alloying Elements to Absorb Hydrogen and Nitrogen. Erich Martin. *Iron and Coal Trades Review*, Jan. 17, 1930, Vol. 120, page 78.
Abstract of an article from "Archiv für das Eisenhüttenwesen." See *Metals & Alloys* April 1930, page 479. RHP (25)

The Behaviour of Dissolved Gases in Cast Iron. J. E. Hurst. *Foundry Trade Journal*, Jan. 2, 1930, Vol. 42, page 3.
Abstract of lecture before Middlesborough branch of Institute of British Foundrymen. Deals with the work of earlier investigators, as to method of producing sound cast iron. Recently thermal and electric methods were used to free metals from dissolved gases. Effect of pre-solidification is to allow dissolved gases to be liberated at point of solidification. Gases in cast iron vary from 1/3 to 3/4 times volume of metal itself. Composition of the gases is hydrogen, nitrogen, carbon dioxide, carbon monoxide and methane. Solubility of gases is much less when metal is solid than in liquid state. Trouble from dissolved gases in cast iron is much less than in any other alloy. VSP(25)

INSPECTION (26)

Testing Fan Pulley Hubs for Porosity. George L. Pyritz. *Machinery*, Mar. 1930, Vol. 36, pages 545–546.
Describes a method of testing fan pulleys hydraulically at a pressure of from 50 to 60 pounds to determine the porosity of the metal. RHP (26)

Examining Arc Welds for Quality. Gerald C. Ward. *Iron Age*, Vol. 125, pages 369–370.
Several methods have been proposed for inspecting finished welds but there is a difference of opinion as to their effectiveness. Discusses results obtained at the University of Wisconsin. Sound tests were considered, but the tests most carefully studied were the kerosene penetration and visual inspection tests. The presence of moderate amount of rust, oil or paint had little effect upon the strength of welds. It was found that in no case did the kerosene penetration test fail to indicate a poor specimen. This test is an excellent index as to the porosity of a weld, but it cannot be used as a criterion for unit breaking stress or strength of weld per lineal inch. Gives results of visual inspection by 31 experienced welders. Results showed that it is impracticable for determining quality of a weld, where inspector is not familiar with method by which weld was made. In conclusion author states that tests are secondary and that emphasis must be placed upon procedure control. VSP(26)

EFFECTS OF ELEMENTS ON METALS AND ALLOYS (27)

The Constitution of Steel and Cast Iron, Section II, Part XIV. F. T. Sisco. *Transactions American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 111–129.
This instalment, the fourteenth and last of the series, discusses briefly the effect of the various alloying metals upon the structure and properties of iron-carbon alloys. The general effect is first described, particularly the lowering of the transformation point in cooling. Following this, the common alloying elements, Ni, Mn, Cr, V, W, Mo, Si and Co, are taken up. WHK(27)

The Condition and Effects of Graphite in Cast Iron. H. R. PITT. *Foundry Trade Journal*, Nov. 14, 1929, Vol. 41, pages 351–352.

Includes discussion. Paper read before the West Riding of Yorkshire Branch of the Institute of British Foundrymen. Discusses the varieties and properties and formation of graphite in cast iron. The effect of the various forms of graphite on properties of cast iron. VSP (27)

Nickel in the Iron Foundry. ARTHUR B. EVEREST. *Foundry Trade Journal*, Jan. 2, 1930, Vol. 42, pages 8–12; Jan. 9, 1930, pages 27–28.

Includes discussion. Basis of papers read before the Institute of British Foundrymen, Glasgow, Nov. 9, and Manchester, Dec. 7, 1929. Addition of nickel to white iron first renders the iron sound, and further additions graphitize it, turning the structure from white to gray. The first addition of nickel leads to elimination of chill in a casting. Nickel seems to act like silicon only more feebly. Replacing silicon by nickel the depth of chill is reduced and softens thin section of casting. Iron containing about 2.5% silicon increases chill depth and casting becomes unmachinable. Through its action on cast iron, nickel increases the density and pressure tightness of heavy sections. These castings are used for handling ammonia, petrol, carbon dioxide, etc. VSP (27)

Nickel-Iron and Porosity. *Foundry Trade Journal*, Jan. 9, 1930, Vol. 42, pages 27–28.

Further discussion based on a paper presented before the Institute of British Foundrymen on "Nickle the in Iron Foundry" by Arthur B. Everest. VSP(27)

Increasing Use of Nickel in Alloys. J. W. FURNESS. *American Metal Market*, April 8, 1930, Vol. 37, page 3; *Iron Age*, Vol. 125, April 10, 1930, page 1087.

A brief outline of current uses. WHB(27)

Zinc in Die-Casting. ROBERT M. CURTS. *American Metal Market*, May 10, 1930, Vol. 37, page 5.

Different types of castings include gravity or permanent mold, pressure die castings, plunger type. Alloy with bases other than zinc are touched upon. WHB(27)

The Influence of Third Metals on the Constitution of Brass Alloys. (Der Einfluss von dritten Metallen auf die Konstitution der Messinglegierungen.) O. BAUER & M. HANSEN. *Zeitschrift für Metallkunde*, May 1929, Vol. 21, pages 145–151; June 1929, pages 190–196; Nov. 1929, pages 357–367; Dec. 1929, pages 406–411.

A systematic investigation was carried out by the authors to throw light upon the commercially important problem of the influence of metals other than Cu and Zn upon the constitution of brass. The investigators point out that the use of Guillet's equivalency coefficients in predicting the structure of ternary special brasses must be regarded as inadequate and urge the investigation of the ternary constitutional diagrams. In the first part of the present paper the influence of Pb is considered. After discussing previous publications on the Pb-Zn-Cu diagram, the authors present their own investigations in detail which cover the range of 52–100% Cu and 0–2.5% Pb. The results mainly obtained by thermal and microscopic methods are reproduced in diagrams and photomicrographs. The original paper includes 46 illustrations. The second part of the publication relates to the influence of Ni. Former work is again briefly reviewed. The authors investigated the range of 65–30% Cu with additions of Ni from 0–20%. The second part of this extensive investigation contains 66 illustrations and a bibliography of some 31 references. A short appendix discloses the influence of Ni additions on the hardness of brass alloys with particular reference to the constituents. EF(27)

Present Status of Growing of Cast Iron. (Das Wachsen von Gusseisen nach dem Stande der bisher vorliegenden Forschungsergebnisse.) P. BARDENHEUER. *Stahl und Eisen*, Jan. 16, 1930, Vol. 50, pages 71–76.

Report No. 158 of the Werkstoffausschuss Verein deutscher Eisenhüttenleute. The causes of the growing of cast iron and the influence of the composition on this tendency are summarized. Growing of cast iron is essentially influenced by dissociation of cementite and oxidation. Increases of volume in heating cast iron in vacuum correspond to the theoretical values as calculated from the dissociation of cementite. Growing is chiefly to be contributed to the dissociation of pearlitic cementite. Oxidation either through dissolved gases in the material or through the atmosphere generally causes a greater volume increase. The minimum temperatures for dissociation of cementite are not yet exactly determined. Growing through dissociation of cementite has a measurable velocity even at 300–400° C. Growing is more pronounced at higher temperatures when oxidation takes place. Density, fine and uniform structure, with a graphite content as low as possible, decrease the inclination to grow. High carbon and silicon contents favor growing, manganese and titanium retard growing, a high phosphorus content diminishes growing. Sulphur has no essential influence, nickel favors and chromium retards or prevents growing. The chemical composition is, in general, of importance for the growing of cast iron, in so far as various elements have a different bearing on segregation and distribution of graphite. GN(27)

Alloy Cast Steel in Theory and Practice. (Legierter Stahlguss in Theorie und Praxis.) A. RYS. *Stahl und Eisen*, April 3, 1930, Vol. 50, pages 423–438; *Krupp'sche Monatshefte*, Vol. 11, April 1930, pages 47–74.

The article deals with the influence of alloys on cast steel, gives the results of tests on the physical and chemical properties of low and high alloy cast steels and considers in detail the application of those steels. By alloying, carbon steels can be improved according to the purpose used. The essential advantages which alloy cast steels offer in relation to plain carbon steels are: higher notch toughness, improved tensile strength and yield point at higher temperatures, better vibration strength and resistance to abrasion, improvement of magnetic properties, corrosive and heat resistance qualities. Besides composition, heat treatment is of importance. Alloy cast steels harden through, even with larger cross-sections, and in many cases permit the use of milder quenching mediums. Heat treatment with variable cross-sections was studied with 9 different alloy cast steels (Ni, Ni-Cr, Cr, Mo, Cr-Mo and V). Ni-Cr steels show the best deep hardening and grain refinement and therefore in total best physical properties. Ni-Mn steels range next. Examples for the practical application of low and high alloy cast steels for various purposes are given. Particularities of production of these alloys are pointed out. GN(27)

On the Hot Tensile Strength of Cast Steel with Small Additions of Nickel and Molybdenum. (Ueber die Wärmfestigkeit von Stahlguss mit geringen Zusätzen von Nickel und Molybdän.) W. LIESTMANN & C. SALZMANN. *Stahl und Eisen*, April 3, 1930, Vol. 50, pages 442–446.

The physical properties of Ni-Mo cast steel were tested at 500° C. The additions to 25 melts of the average composition 0.2% C, 0.8% Mn, 0.25% Si amounted to 0.4–2.2% Ni and 0.2–6% Mo. After annealing the samples at 900–950° C. the physical properties (tensile strength, yield point, elongation and reduction of area) were tested at 500° C. The results are: (1) Tensile strength and yield point are essentially improved in comparison to non-alloy cast steel. (2) Yield point and tensile strength increase with increasing nickel and molybdenum contents, elongation and reduction of area, however, decrease. (3) Adding 0.1% Mo increases the yield point by about 1 kg./mm.², and the tensile strength by about 2 kg./mm.² An increase of yield point by 2 kg./mm.² and of tensile strength by 1.8 kg./mm.² is obtained by alloying 0.5% Ni. (4) The relation between yield point and tensile strength is more favorable with increasing nickel contents, but more unfavorable with increasing molybdenum contents. GN(27)

Effects of Silicon on the Properties of Brass. H. W. GOULD & K. W. RAY. *Metals & Alloys*, Vol. 1, Part I, April 1930, pages 455–457; Part II, May 1930, pages 502–507.

Constitution. A study of the 85–15 and 60–40 silicon brasses is made. The structure has been examined. Silicon forms homogeneous α-solutions with 85–15 brass if present to the extent of not more than 2.8%. It does not form homogeneous α-solutions with 60–40 brass. The range for mixed α and β solid phases is about 2.8–5.2% silicon for 85–15 brass, and 0% to about 2% silicon for 60–40 brass. Silicon forms a homogeneous γ-solid solution with 85–15 brass at 8.6% and with 60–40 brass at about 4.2%. All other brasses in 2 series show 2 solid phases. Silicon lowers the freezing point of the 85–15 and 60–40 brasses when present in amounts up to 10 and 7%, respectively. Many of the silicon brasses are subject to heat treatment. Data and graphs are presented to indicate several conclusions. It is found that the specific gravity of a brass is uniformly decreased by increasing percentages of silicon. The hardness is rapidly increased by silicon until a maximum is practically reached at 9% silicon for the 85–15 brass and at 7% silicon for the 65–35 and the 60–40 brasses. An 85–15 brass begins to become brittle at about 6% silicon, a 65–35 brass at 3% and a 60–40 brass at 2% silicon. The tensile strength increases to a maximum at about 4.5% silicon for 85–15 brass and at 1.5% silicon for the 60–40. The decrease in both tensile strength and percentage elongation is rapid after the maximum is exceeded. Small percentages of silicon produce a fine compact structure in all cases. Silicon brasses cast more easily 2–5% silicon in 85–15 brass and 1–3% in 60–40 brass produce a beautiful gold yellow to silver gray color. Higher percentages produce a dull slate gray color. 85–12 brass containing less than 2% silicon can be sawed, drilled and threaded. They can be readily machined at high speed. Silicon has little effect in general on the corrosion resistance of 85–15 and 60–40 brasses except when present in amounts sufficient to give an open porous structure in which case rate of corrosion is increased. Most of the silicon brasses are subject to heat treatment. Silicon may be used in brasses where hardness and toughness are required, provided lead and aluminum are absent. ESC(27)

INSTRUMENTS AND CONTROLLERS (28)

Temperature Measurements in Open Hearth Furnaces. (Temperaturmessungen an Siemens-Martin-Oefen.) ALFRED SCHACK. *Archiv für Eisenhüttenwesen*, July 1929, pages 7–12.

Report No. 169 of the *Stahlwerksausschuss of the Verein deutscher Eisenhüttenleute*. The apparatus and furnaces are described. The results give the decrease in temperature of the waste gases from the head to the checkers, the influence of false air, gas entering the air checkers, delayed combustions. Bath temperatures are measured, also draft. GN(28)

Measuring Temperatures of Colored Flames Optically. (Optische Temperaturmessung an gefärbten Flammen.) H. SCHMIDT. *Stahl und Eisen*, Jan. 23, 1930, Vol. 50, pages 106–107.

Two optical methods to determine high temperatures, as for instance temperatures in an open hearth furnace, are considered. The one method is based on the reversion of the spectrum lines according to Kurlbaum and the other on the observation of the spectrum of means which are applied for coloring flames. Alkali or alkali earth metals are used in this case. GN(28)

Automatic Temperature Control Chromium Plating Solutions. R. W. SAUNDERS. *Metals & Alloys*, Feb. 1930, Vol. 1, pages 368–370.

It has been found that chromium plating must be carried out under definite conditions of temperature, current density, and solution composition to give satisfactory results. Solution composition depreciates very slowly in proportion to the deposition of metallic chromium on the work. Current density is constant where once established. Temperature varies due to resistance of solution in process, and to lack of circulation when no work is present. Majority practice utilizes a heating unit until the desired temperature is reached and thereafter cooling medium is controlled. Various suitable adaptations of equipment for automatic temperature control are described. Normally gassing takes care of circulation. Agitation does not affect the plating. ESC(28)

EFFECT OF TEMPERATURE ON METALS AND ALLOYS (29)

Dilatometric Experiments of the Thermic Effects When Tempering Duralumin and Its Structural Constituents. M. HAAS & H. HECKER. *Metals & Alloys*, Sept. 1929, Vol. 1, pages 124–130.

Translation of an article from *Zeitschrift für Metallkunde*, May, 1929, pages 166–173. (29)

Building Vessels for High Pressure and High Temperature Service. T. MCLEAN JASPER. *Mechanical Engineering*, March 1930, Vol. 52, pages 193–200.

Abstract of a paper before World Engineering Congress, Tokyo, Japan, Oct. 20–25, 1929. In dealing with the subject the author considers among the most important points for a successful service of thick-walled vessels, careful selection and testing of materials especially at the high temperatures vessels encounter. GN(29)

Some Alloys for Use at High Temperatures. Nickel-Chromium and Complex Iron-Nickel-Chromium Alloys. Part I. W. ROSENHAIN & C. H. M. JENKINS. **Part II.** C. H. M. JENKINS, H. J. TAPSELL, C. R. AUSTIN & W. P. REES. *Iron & Steel Institute*, May 1930, *Advance Copy* 1, 80 pages; *Iron & Coal Trades Review*, May 16, 1930, pages 800–804; *Engineer*, Vol. 149, May 16, 1930, pages 538–539; *Engineering*, Vol. 129, June 20, 1930, pages 811–813.

An extensive and detailed report on the high temperature properties of the alloys of nickel and chromium has been published by the National Physical Laboratory. This research is one of those being made under the auspices of the Engineering Research Board of the Department of Scientific and Industrial Research, and is concerned with the evolution of high temperature alloys which may be expected to satisfy the exacting demands of present and future high temperature engineering practice; special attention is being devoted to the question of resistance to creep under prolonged loading at temperatures between 650° and 800° C. (1200° and 1470° F.). The first section of the paper relates to the preparation and mechanical properties of binary nickel-chromium alloys containing chromium 0–60%, dealing chiefly with the range 20–40% nickel. A further section covers a study of the recrystallization in cold worked nickel-chromium alloys containing, respectively, 80, 70 and 60% nickel. In the study of the alloys of nickel and chromium containing iron, two series of materials were prepared containing (1) low carbon, generally less than 0.05% and (2) containing approximately 0.5% carbon. The final section of the report deals with complex nickl-chromium-iron alloys containing tungsten, molybdenum, vanadium, aluminum, titanium, singly or in combination and with two high-nickel, high-chromium steels (nickel 27, chromium 14). The paper contains a very large amount of tabular and graphical data and is extensively illustrated by photomicrographs; the range covered is too wide to permit of a condensed abstract of the results and the original should be consulted for information on the properties of the individual alloys studied. The authors consider that the preliminary results obtained indicate the possibility of the development of materials having high temperature properties markedly superior to those of the alloys which are now commercially available, and it is believed that the results of the experiments already carried out have an important bearing on future developments.

LM + AEH(29)

The Response of Steels at Elevated Temperatures. W. H. HATFIELD. *Journal West of Scotland Iron & Steel Institute*, Vol. 36, 1928–1929, pages 58–64.

The author emphasizes the disadvantages of forms of "creep" tests which involve prolonged periods for their execution, and described a method evolved at the Brown-Firth Research Laboratories for the rapid determination of a value known as the "Time-Yield," which is believed to give reliable guidance for engineering purposes. The method adopted "consists in discovering, by static loading the stress within which at the temperature, in question, stability of dimensions is attained within a period of 24 hours for a further period of 48 hours, with an extension not exceeding the elastic deformation of 0.5% on the gage length, with limitation as regards measurement for permanence of dimensions of one-millionth of an inch/inch/hour." This value is taken as the "time-yield." The practice of regarding $^2/_3$ of the "time-yield" of a steel at any given temperature as a safe working stress for the material has been found to give satisfactory results over a considerable period. The author gives "time-yield" values for a mild steel, a nickel steel (nickel 3%), a nickel-chromium-molybdenum steel and a modified nickel-chromium steel containing 3.75% of tungsten. A number of tables are also included, giving data on the ordinary tensile properties of steels of various types over a wide range of temperature. Brief reference was made to the work of various investigators on fatigue and impact resistance at elevated temperatures. In general, it has been found that the fatigue range of steels at high temperatures does not fall as rapidly as would be expected from a consideration of the effect of the corresponding temperatures on tensile strength. Within the range of steam temperatures, resistance to impact increases with rise of temperatures. Oxidation resistance was dealt with by means of a study of the effect of exposure of different types of steel for six hours to the action (at 540° C.; 1000° F.) of steam formed from water containing 5 cc. of oxygen/liter. A gain in weight of only 0.01 mg./cm.^{2} of surface was shown in the case of a steel containing nickel 8, chromium 18%, as compared with 0.62 mg. for a 0.25% carbon steel. Dealing with heat-resisting steels, the author referred briefly to recent outstanding literature on the subject and gave details of tests made in the Brown-Firth Laboratories on steels covering a wide range of composition. The results indicate that while the effect of additions of nickel, chromium or tungsten singly have only a slight effect on the stability of steel at high temperatures, a judicious combination of the 3 elements, with a suitable percentage of carbon, produces materials which show very high tensile strength at raised temperature. The paper closes with a table showing the comparative effect on mild steel and on a number of special steels of exposure at 900° C. to gases corresponding in composition to products of combustion. As typical of the enhanced resistance obtainable in complex steels, the index figure for the oxidation of mild steel under these conditions is given as 80.225 and that of nickel-chromium-tungsten steel as 0.43. (29)

LEACHING (30)

Hydrometallurgy of Copper at the Bagdad Property. CHARLES T. BAROCH. (Bagdad Copper Corp.) *Preprint* 57–26, *American Electrochemical Society Meeting*, May 29–31, 1930, pages 285–309.

The ore minerals are principally chalcopyrite and chalcocite. Copper in the ore averages 1 to 1.25%. After roasting the ore it was leached with spent sulphate electrolyte, resulting in copper extractions as high as 91%. The solution builds up in copper to a concentration of 60 g./L. and more, the free sulphuric acid dropping to 10 g./L. By diverting part of the spent electrolyte into this solution coming from the extraction plant, the copper is brought down to 50 g./L. and the acid up to 25 g./L., resulting in an electrolyte of good electrical conductivity. The current density of the copper cells is 20 amp./sq. ft. (2.1 amp./sq.dm.). Cell voltage has ranged from 1.97 to 2.12 volts. (30)

Germanium in Relation to Electrolytic Zinc Production. U. C. TAINTON & E. T. CLAYTON. (Evans-Wallower Zinc Co.) *Preprint* 57–28, *American Electrochemical Society*, May 29–31, 1930. pages 321–328.

Certain impurities in the zinc solution, if not removed, will deposit with the zinc and lower the overvoltage below the critical point. In the "high-acid high-density" process, Sb, Co, Ni and As, which are objectionable impurities, are readily removed. However, a hitherto unsuspected impurity which gave rise to low current efficiencies was, after careful investigation, found to be germanium. Concentrations as low as 1 mg./L. are sufficient to cause serious losses in efficiency. Germanium may be adsorbed and removed from solution by means of ferric hydrate precipitated by zinc oxide in the leaching operation. (30)

REDUCTION METALLURGY (31)

Taking of Solid and Liquid Samples from the Blast Furance. (Entnahme von festen und flüssigen Proben aus dem Hochofen.) GEORGE BULLE. *Archiv für Eisenhüttenwesen*, Sept. 1929, Vol. 3, pages 169–172.

Various pieces of apparatus for taking solid and liquid samples from the shaft, boshes and hearth of a blast furnace are described. (31)

Blast Furnace Temperature Measurements. (Temperaturmessungen am Hochofen.) P. RHEINLANDER. *Archiv für das Eisenhüttenwesen*, Feb. 1930, Vol. 3, pages 487–503; *Stahl und Eisen*, Feb. 1930, Vol. 50, pages 205–206.

Paper before the 7th meeting of the Blast Furnace Committee of the Verein deutscher Eisenhüttenleute, Sept. 27, 1929. Temperatures of three blast furnaces were measured with optical pyrometers, radiation pyrometers and thermocouples. Temperatures in the level but close to the tuyères, as measured by optical pyrometers differ considerably. Temperature decreases toward the center of the level of the tuyères. The average temperature is 1740° C. Fluctuations of temperature, short in time, indicate irregular working of the blast furnace. Location of scaffolding could be determined by temperature fluctuations in front of tuyères. Relation between temperature and metallurgical behavior were investigated. GN(31)

Norwegian Electric Pig Iron Contains Alloys. *Iron Age*, Feb. 13, 1930, Vol. 125, page 508.

Taken from British Iron and Steel Industry. Norskalloy is the name of a Norwegian branch of electric furnace pig iron produced from ores containing vanadium and titanium. The chemical analysis is:

	Standard %	Refined %
Total carbon	4.0 to 4.5	2.5 to 3.5
Silicon	0.5 to 1.5	1.70 to 2.5
Manganese	0.20	0.20
Sulphur	Trace	Trace
Phosphorus	0.20 to 0.25	0.15 to 0.20
Vanadium	0.30 to 0.40	0.20 to 0.30
Titanium	0.40 to 0.80	0.30 to 0.50

Traces of other elements found present such as beryllium, while if required, nickel and chromium may be added. VSP(31)

Reactions during the Roasting of Nickel Ore Containing Copper. (Ueber die Vorgänge beim Verblasen von Kupferhältigem Nickelstein.) VICTOR TAFEL & FRITZ KLEWETA. *Metall und Erz*, Feb. 1930, Vol. 27, pages 85–88.

Nickel ore free from copper is difficult to reduce, but in the presence of copper it is much easier to accomplish. From a study of the reactions taking place in the converter it was found that this is due to the reaction $Cu_2S + 2NiO = 2Cu + 2Ni + SO_2$. This reaction takes place especially above 1300° C. An acid converter cannot be used for this purpose. CEM(31)

Alkaline Electrolytic Iron. S. J. LLOYD. *Canadian Mining Journal* Dec. 13, 1929, Vol. 50, pages 1185–1188.

Some experimental data on the Estelle process. WHB (31)

Producing Artificial Manganese Ores. T. L. JOSEPH, E. P. BARRETT & C. E. WOOD. *Technical Publication* 310, *American Institute Mining & Metallurgical Engineers; Iron Age*, Mar. 6, 1930, Vol. 125, pages 723–724.

Describes the work of the Bureau of Mines and Minnesota School of Mines, on the methods for recovering manganese content of magniferous iron ores in form suitable for the production of ferromanganese. Two types of magniferous iron ores are available: brown ores and black ores. Experimental work was conducted with a 6-ton blast furnace and a $^1/_2$-ton basic open-hearth. Concerned mainly with open-hearth tests in which high phosphorus spiegel was treated. Results show that spiegel from Cuyuna magniferous iron ores can be treated also in electric furnace. Under present practice, sufficient manganiferous iron ore is added to ore mixtures of blast furnace making basic iron, to produce metal containing from 1.2–2.0% Mn. The Mn is diluted with lime, silica and alumina, and contaminated with phosphorus so as to limit its use in making high Mn pig iron. About 15 blast furnaces with total daily capacity of 6000 tons of spiegel containing 15% Mn would be required to produce enough high Mn slag to make 300,000 tons of ferromanganese annually. VSP(31)

Advent of the 1000-Ton Blast Furnace. A. G. MCKEE. *Iron & Coal Trades Review*, Jan. 3, 1930, Vol. 120, page 5; Jan. 10, 1930, pages 41–42. *Blast Furnace & Steel Plant*, Dec. 1929, Vol. 17, pages 1805–1809. *Iron Trade Review*, Nov. 28, 1929, Vol. 85, pages 1369–1373. *Iron Age*, Jan. 2, 1930, Vol. 125, pages 37–39.

Abstract of a paper read at the third annual meeting of the American Society of Mechanical Engineers, Cleveland. Discusses the trend toward larger furnaces and the use of blast furnace gases for underfiring coke ovens, making open-hearth steel and other heating throughout the mill. Describes the construction of these furnaces, the fuels used and the method of operation. RHP (31)

The Estelle Process—Electrolytic Reduction of Iron from Its Ores. A. ESTELLE. *Canadian Mining Journal*, Nov. 29, 1929, Vol. 50, pages 1137–1140; *Transactions American Electrochemical Society*, 1929, Vol. 55, pages 305–314.

A reprint of an article appearing in the same journal Oct. 1922. A description of the author's process for the electrolytic reduction of iron from its ores. WHB (31)

Operators Explore Possibilities in 1000-Ton Blast Furnace. *Iron Trade Review*, Jan. 2, 1930, Vol. 86, pages 20, 29.

Review of progress as seen by several blast-furnace men. Tendency is to enlarge existing stacks to smelt 1000 tons or more of pig-iron. Profitable use is being made of blast-furnace gas for underfiring coke-ovens, melting open-hearth charges and reheating steel in rolling-mill departments. MS (31)

Controlling Furnace Burden by Gas Analysis. C. C. FURNAS. *Blast Furnace & Steel Plant*, Dec. 1929, Vol. 17, pages 1791–1796, 1800. *Iron & Coal Trades Review*, Jan. 10, 1930, Vol. 120, page 37. *Industrial & Engineering Chemistry*, Jan. 1930, pages 26–31.

Report of work carried out by the U. S. Bureau of Mines on blast furnace control. Discusses the relation between the average CO_2 content of the top gas of the furnace and the amount of fuel necessary to maintain a given hearth heat. When furnaces run hot and cold without change of external conditions it is probably caused by a slow deoxidation in upper part of the furnace with a consequent excessive reaction between CO_2 and carbon in the lower part of the furnace which causes greater solution loss than would occur if all reduction had taken place in the upper part of the furnace. Analysis of the top gas of the furnace will indicate the condition of the furnace immediately, whereas the hearth temperature and metal do not react for hours. This makes possible more accurate control with better results as a consequence. The remedy is to charge additional coke into the furnace. The charts given in this paper are intended to show how much coke is needed. Bibliography of nine references. RHP(31)

Gas Flow in Blast Furnaces. *Iron & Coal Trades Review*, Vol. 120, Feb. 21, 1930, page 318.

Abstract of U. S. Bureau of Mines report No. 2978. This paper dealing with the "Irregular Gas Flow in Blast Furnaces" points out the following facts: (1) the composition of the gas on any plane in the shaft of the furnace is not uniform; (2) the flow of gas in the column is not uniform; (3) a relatively high temperature exists where the gas velocity is high and the gas at these points is generally low in CO_2. Discusses the possibility of control of the flow and percentage mixture of the gases and the results which might be expected from such control. AHE & RHP(31)

Vanadium Ores. *Vancoram Review*, Vol. 1, Apr. 1930, pages 69–72.

The world's outstanding deposit of vanadium ore is at Mina Ragra, Peru. Since 1906 when the deposit was discovered, three-fourths of all vanadium used in the world came from this mine. The early methods of mining are briefly described, and the recent improvements are mentioned. Other bodies of vanadium ore are located in Southwest Africa, Northern Rhodesia, Arizona, Nevada, New Mexico, Colorado, Utah, Mexico, Spain and Argentine. (31)

The Dwight-Lloyd Sintering Process. H. WITTENBERG. *Metallgesellschaft*, May 1930, pages 3–9.

Gives a description of the process, a detailed account of the equipment and a table of production costs. MLM(31)

The Magnetic Concentration of Certain Natural and Artificial Manganese Dioxides. T. J. MARTIN. (Burgess Battery Co.) *Preprint* 57–24, *American Electrochemical Society*, May 29–31, 1930, pages 257–269.

This article gives the results of magnetic concentration tests on a number of natural and artificial manganese dioxides, which are weakly magnetic. The extractions are made at various magnetic intensities, on the material ground to several degrees of fineness. The MnO_2 content of the several fractions is given. The data show that it is not possible to remove highly magnetic impurities from all manganese ores efficiently, with the flux densities used. Fine grinding of the ores results in a less efficient separation than coarse grinding. Each ore requires special adjustments to get the best operation. (31)

Studies on the Reduction of Iron Ore. (Undersökning av Forlöppet vid reduktion av Järmalm II.) BERTIL STALHANE & TORE MALMBERG. *Jernkontorets Annaler*, Vol. 114, Jan. 15, 1930, pages 1–26.

In a previous communication (*Jernkontorets Annaler*, Vol. 113, (1929), page 95) the theory of the reduction of Fe ore has been developed. The present paper is an experimental test of the theory on small particles (less than 5 mm. diam.) in the temperature range 900–1000° in CO. The effect of mixing the CO with CO_2 was studied. It was found that the reduction goes primarily through Fe_3O_4 and FeO to Fe. It begins at the outside and penetrates inward. In normal reduction the final product is 95% sponge Fe. Complete reduction required relatively long time (greater than 30 min.). Carbon deposition begins near complete reduction. When CO_2 is present the carbon deposition may be completely inhibited. The speed of reduction is determined by the rate of the reaction $(FeO)n + nCO \rightleftharpoons (Fe)_n + nCO_2$, and the rate of diffusion of the gaseous components. The reduction Fe_3O_4 goes rapidly at first and slows up the reduction of FeO. At 900° C. there is a discontinuity in the time temperature curve probably because of the changed character of the reaction in the transformation of α-iron to β-iron. Thus the reaction with CO is more rapid at 890° C. than at 910° C. HCD(31)

An Experimental Inquiry into the Interaction of Gases and Ore in the Blast-Furnace. Part II. Carbon Deposition at 450° C. and Its Influence upon the Ore Reduction; Equilibria between Gases and Ore at 650–1000° C. WILLIAM A. BONE, L. REEVE & H. L. SAUNDERS. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 4, 48 pages; *Engineer*, Vol. 149, May 9, 1930, pages 516–517; *Engineering*, Vol. 129, May 16, 1930, pages 647–650.

This paper gives the results of an investigation into the deposition of carbon at temperatures below 550° C. and other factors in blast furnace practice. A comparison is made between the relative reducing powers of the so-deposited carbon and carbonic oxide upon oxides of iron at temperatures above 650° C. The equilibrium ratio of CO/CO_2 in systems containing Fe_xO_y, Fe, CO and CO_2 has been determined. An investigation has also been made of the separate and combined influences of such factors as temperature, "distant potential" of the gases from their resultant equilibrium point and gas velocity upon the rates of ore reduction and carbon deposition at various selected temperatures. LM + AEH(31)

Continental Blast Furnace Practice. F. CLERF. *Journal West of Scotland Iron & Steel Institute*, Vol. 37, Jan. 1930, pages 51–76.

Includes discussion. Deals with two groups of iron producers: those that smelt French minette ores, and those smelting other foreign ores. Included in the first group are: the iron producers of Lorraine, those of the Saar district, and the iron producers of northern France and Belgium. The second group includes all the large furnaces of the Ruhr and Rhine valleys. Describes various types of ores giving a map showing location of the deposits. Also deals with production of basic Bessemer pig-iron, raw materials, blast furnace practice of various localities and methods of gas cleaning. Gives numerous drawings. LM(31)

The Purification of Bauxite. *Engineering*, Vol. 129, May 2, 1930, page 571.

Comments on Bulletin 312 of U. S. Bureau of Mines, "Bauxite, Float-and-Sink Fractionations and Flotation Experiments," by G. W. Gandrud & F. D. de Vaney. Due to fact that many deposits are of low grade, new methods of concentration and purification of bauxite had to be developed. LM(31)

The Manufacture of Ferro-Vanadium. *Vancoram Review*, Vol. 1, Apr. 1930, pages 73–78.

The present day metallurgical processes for vanadium ores: Patronite-vanadium sulphides, sulphates and oxides (Peru) direct electric reduction by carbon, and by roasting, leaching, precipitating the V_2O_5 concentrate and alumino-thermic reduction; Rascaelites—Vandiferous mica in sand stone (Cal. Utah) roasting leaching precipitating the V_2O_5 concentrates and and alumino-thermic reduction; Carnotite-uranyl potassium vanadate (Col. & Utah) wet or dry elutriation, alkaline leach, precipitating the V_2O_5, duplex electric reduction by silicon; Metallic Vanadates—acid leach, precipitating as iron vanadate and alumino thermic reduction. (31)

GENERAL (0)

Technical and Commercial Trends in the Junior Metal and Mineral Industries. G. C. RIDDELL. *Mining & Metallurgy*, Jan. 1930, Vol. 11, pages 43–50.

Activity in the minor minerals and metals the past year was due to expansion in aviation, radio and automatic mechanical equipment. The General Electric Co. succeeded in putting quartz, melting point 3200° F., into sheet form at reasonable cost. Quartz glass is now used instead of window glass, which, unlike window glass, admits the beneficial ultra-violet rays. Work on cosmic rays shows that there is a close relation between the various types of cosmic rays and the elements composing the universe, each ray corresponding to the birth of an atom of some element. Helium is being produced in large quantities by the U. S. Bureau of Mines at Amarvillo, Texas, at less than $20 per M cu. ft. The process used is the low-temperature method developed by the Bureau. Germany is seeking synthetic helium but its success is doubtful. In Germany it was discovered that hydrogen exists in two molecular forms. It is claimed to be the greatest chemical achievement of the year. Discusses development of electronic engraving. Non-ferrous cutting alloys, corrosion resistant alloy steels and iron, light weight alloys, die casting alloys are making inroads into ferrous activities. Aircraft manufacturers are using alloys of aluminum, chromium, chromium-molybdenum, etc. Magnesium alloy propeller blades are being produced. The autochrome process has been developed for the conversion of ordinary iron and steel into chromium iron and steel by direct use of chrome ore. Other processes discussed are: chrome plating and stelliting; beryllium, chromium, cobalt, tungsten, molybdenum, monel metal, cadmium, titanium, barium, strontium, lithium, tantalum, columbium, caesium, rubidium, radium, antimony, bismuth, quicksilver, selenium, tellurium, magnesium. VSP(0)

Development Program May Restore Prestige of Cast Iron. L. W. SPRING. *Iron Age*, Nov. 14, 1929, Vol. 124, pages 1321–1322.

Paper before Chicago Section of the American Chemical Society. See *Metals & Alloys*, May 1930, Vol. 1, page 521. VSP(0)

Notable Progress in Steel Research. *Iron Age*, Oct. 24, 1929, Vol. 124, pages 1111–1112.

Discusses the third annual meeting of the Metallurgical Advisory Board to the Carnegie Institute of Technology and the United States Bureau of Mines held at Pittsburgh. Dr. C. H. Herty, Jr., reported on the study of non-metallic inclusions in steel, with particular reference to the chemical reactions between metal and slag in open-hearth furnaces and the cause of "dirty" steel. The high spot of the report was in the announcement of the discovery of new methods of measuring somins in steel. Report on the studies made for the random grouping of crystal aggregates after carburizing by Dr. V. N. Krivobok. Studies are also being continued on commercial cast manganese steels of the Hadfield type. Another investigation being conducted concerns development of steels made with alloys produced in the U. S. which may be substituted for others made with imported metals. VSP(0)

Authorities Express Opinions on 1929 Engineering Progress. *Iron Trade Review*, Jan. 9, 1930, Vol. 86, pages 24, 32.

Notable advances are made in blast-furnace practice, welding of structural steel, and heat treating equipment and operations. MS(0)

To Cast or to Weld. M. TAYLOR. *Iron Age*, Vol. 125, Mar. 20, 1930, pages 861–862.

The use of fabricated steel base-plates for machines is discussed, and the possibility of effecting saving in weight and cost pointed out. VSP (0)

Recent Developments in Nickel Iron and Steel. CHARLES MCKNIGHT. Advance paper, American Iron & Steel Institute, May 9, 1930, 17 pages; *American Metal Market*, Vol. 37, May 15, 1930, pages 8, 10; May 16, 1930, page 10; May 17, 1930, pages 8, 10; *Engineering*, Vol. 129, June 6, 1930, pages 750–751; The Mining Journal, Vol. 169, June 28, 1930, pages 522–523.

A review. The only recent development in structural automotive steels is that of nickel-molybdenum steels. Nickel cast iron has increased enormously in use. The use of nickel for corrosion resistant materials increased 400% in 1929, also for heat-resisting alloys. LM + WHB(0)

Progress in Metallurgical Research. H. C. H. CARPENTER. *Iron & Coal Trades Review*, Vol. 120, Jan. 24, 1930, pages 152–153.

The most important event in British research progress in 1929 was the formation of an Iron and Steel Industrial Research Council. Brief reviews of some of the more important papers presented throughout the year are presented. General and brief mention is made to some of the other problems which have been worked on during the year including nitriding and high-tensile structural steels. RHP(0)

British Foundrymen Cast Variety of Alloys. THOMAS H. TURNER. *Foundry*, Vol. 57, Pt. I—Cast Iron, Nov. 1, 1929, pages 903–906; Pt. II—Steel, Nov. 15, 1929, pages 956–957; Pt. III—Yellow Metals, Dec. 1, 1929, pages 993–996; Pt. IV—White Metals, Dec. 15, 1929, pages 1040–1042; Pt. V—Light Alloys, Vol. 58, Jan. 1, 1930, pages 121–123; Pt. VI—Nickel Alloys, Jan. 15, 1930, pages 90–91. *Foundry Trade Journal*, Vol. 41, Nov. 21, 1929, pages 372–373; Dec. 12, 1929, pages 428; Dec. 26, 1929, pages 457–458, 462; Jan. 16, 1930, Vol. 42, pages 43–44; Jan. 30, 1930, pages 81–82; Feb. 6, 1930, pages 107–108.

An abstract of a paper presented before the French Association Technique de Fonderie. The use of specifications for cast iron has not become universal in Great Britiain as is the case with some of the non-ferrous alloys. The chemical compositions for cast iron and malleable cast iron for automobiles are considered less important than the mechanical properties. Gives B. E. S. A. specifications for cast irons, cylinder irons, alloy cast irons and semi-steel mixtures. High tensile alloy steel castings are seldom made in Great Britain, despite the important part that nickel, nickel-chromium and other such alloy steel forgings play in modern engineering. Plain carbon steel castings are produced that are comparable to those of other countries. Manganese steel with 13% manganese and stainless steels with 13% chromium, or 18% chromium and 8% nickel are used for certain types of castings. Includes chemical and physical data for these steels. Alloys rich in copper are manufactured in great variety of compositions and mechanical properties. Gives B. E. S. A. specifications for the various alloys. Tabulates the chemical and physical properties of the various copper alloys grouped under the heading of yellow metals. Alloys containing large amounts of lead or tin are known as white alloys. Presents analyses and uses of the alloys. The B. E. S. A. recently published specifications for these alloys, as to their composition and suitable plain bend and reverse bend tests. Under light alloys discusses an alloy recently developed and known as Y-alloy or L24. The composition of this alloy is 4% copper; 2.0% nickel; 1.5% magnesium, and remainder aluminum. Used for castings such as internal combustion engine pistons, but is also used for many other highly stressed parts and resists corrosion. Other light alloys discussed are: silicon-copper-aluminum alloy having a composition 8% copper; 2.5% silicon; 0.8% iron and remainder aluminum; zinc-aluminum-magnesium alloy containing 3.5–6.5% aluminum; 2.5–3.0% zinc; 0.25–0.75% manganese, and remainder magnesium, and an aluminum-magnesium alloy containing 10% aluminum; 0.25–0.50% manganese, and remainder magnesium. Contains tables giving the chemical composition, physical properties and normal range of the light alloys. Alloys resistant to corrosion, electricity or heat are dependent upon nickel for their resistant properties. Copper and chromium are present in large quantities, and tungsten, manganese, silicon and aluminum in small quantities. The alloys mostly used are: cast nickel silvers, cast copper-nickel alloys, malleable cast nickel, cast austenitic nickel-chromium steels, and special cast irons. There are no specifications for any of these resistant alloys. Includes table giving properties of the alloys. VSP(0)

Foundries Turning Efforts Toward Improvement in Quality. *Iron Trade Review*, Jan. 2, 1930, Vol. 86, pages 23, 121.

Statements of several experts show that attention is being given to metallurgical fundamentals. MS(0)

Non-Ferrous Metals and Alloys. III. GEORGE M. ENOS. *Modern Machine Shop*, Vol. 2, April 1930, pages 46–54, 76.

This article, which is the third and last of the series, deals with the light aluminum alloys. It discusses the metallography of the alloys, their uses, physical properties and heat treatment. MLM(0)

Modern Development of Alloy Steel (Neuzeitliche Entwicklung des Edelstahls). P. GOERENS. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 74, Mar. 8, 1930, pages 297–302.

From a report to the World's Engineering Congress. Since the beginning of this century, a very rapid development in the production of alloy steel has set in due to the very exacting demands made by the machine industry as well as by the chemical industry. Purity of the starting material assures and simplifies the production of good alloy steel. In this paper, the influence of the manufacturing process and successful overcoming of certain general defects are discussed. The importance of tensile tests is emphasized and the magnetic properties and other mechanical qualities are investigated. Progress in the field of tool-steels, rust-resisting steels and heat-resisting steels are reported and compositions for attaining certain properties are given. In conclusion, treatments are indicated to assure a greater resistance to corrosion. HA(0)

The Manufacture of Tube Steel. J. C. BOOTH. (Partington Steel & Iron Company, Limited.) *Iron & Coal Trades Review*, Vol. 120, Mar. 14, 1930, pages 446–447.

Steel for tube making should be fairly low in silicon, 1 – 1.5% phosphorus, 1 – 4% manganese, and as low sulphur as possible. For rimmed steel the composition of the charge entering the furnace should be clean stock of 40% pig and 60% scrap with no ore. The thickness of the sound skin of the ingot depends on the degree of the boil in the furnace, which is obtained by: 1, proper composition of the charge; 2, correct oreing, and 3, regulation of working temperature. Casting temperature should be approximately 1580° C. Unsegregated steel is the normal type of steel. Its manufacture requires great care. The slag must be good to produce good steel. The most essential properties of a slag are reactivity and fluidity. Oxygen in the slag must be kept as low as possible since the oxygen in the steel is directly proportional to the oxygen in the slag. The total oxide should not exceed 26% of the slag. Gives composition and discusses various slags. Main sources of oxygen in the metal are: 1. that in solution due to contact with an oxidizing slag; 2. the oxygen picked up during tapping. Elimination of oxygen to 0.04% is sufficient. The best composition to insure fluidity is approximately 20% SiO_2. Ingot molds should be designed so that the metal will freeze upward. Ingots should never be laid flat until the interior is solid. Ingots should never be heated in a horizontal position; nor should they be placed in a direct flame, as local burning may result. Large surface defects appear immediately. Small ones may not be detected till the end of the process. Galvanizing readily detects these. Polishing methods for the examination of metals for inclusions are discussed. RHP(0)

Mill Rolls Large Aluminum Shapes. *Iron Age*, Vol. 125, Mar. 6, 1930, pages 707–710.

Structural mill rolling channels up to 14 in. as well as other shapes, flats, squares and rounds, were put into service by the Aluminum Co. of America, at Massena, N. Y. Pig aluminum is melted in four coke-fired furnaces having a capacity 20,000 lb. Three sizes of ingots are made. Freezing of ingots is controlled by regulating the temperature. Formation of pipe is prevented by releasing the gases in aluminum gradually. The blooming mill is the largest aluminum rolling mill in the world, having 38 × 84 in face rolls. Light lubricating oil is flushed over the rolls. Rolling of aluminum alloys produces no mill scale. Semi-finished metal is passed through pusher type oil-heated furnace. Shapes are heat treated and quenched. Aging is done in oven which can receive shapes up to 90 ft. Structural shapes are rolled from three alloys: (1) Copper alloy containing 4% Cu, 0.5% Mg and 0.5% Mn; (2) 4.5% Cu, 0.8% Si and 0.8% Mn, and (3) almost pure aluminum containing 0.6% Mg and 0.1% Si. Advantages of solution heat treatment and aging. Effect of heat treatment on physical properties. Electricity is used to reduce alumina by electrolysis to aluminum. Power consumed for one pound of aluminum is about 15 HP-hr. VSP(0)

Department of Scientific and Industrial Research. *Iron & Coal Trades Review*, Vol. 120, Feb. 7, 1930, page 235.

Report of the Advisory Council of the Department of Scientific and Industrial research, for the year of 1928–1929. An Industrial Research Council was formed during the year by the National Federation of Iron and Steel Manufacturers. This council will not undertake independent metallurgical investigations but will aid in the collaboration of material from research and its application to industry. RHP(0)

Recent Advances in the Theory of Metals. *Engineering*, Vol. 129, May 9, 1930, pages 595–597.

From Kelvin lecture delivered before the Institution of Electrical Engineers by R. H. Fowler. Deals mainly with applications and results of quantum mechanics. Refers to work of many investigators, explaining and commenting on their theories. LM(0)

Atomic Nuclei and Their Structure. *Engineering*, Vol. 129, March 21, 1930, pages 371–372; March 28, 1930, pages 397–398; April 4, 1930, pages 437–438; April 11, 1930, pages 470–471.

From a series of lectures delivered by Sir Ernest Rutherford before the Royal Institution. Reviews and discusses theories of various investigators LM(0)

Ascendancy of Alloy Castings. E. F. Cone. *Iron Age*, Vol. 124, Aug. 1, 1929, pages 282–283.

The article includes a number of details on alloying practice in the manufacture of locomotive and automobile parts, and a revised table showing output of alloy iron castings from 39 of the U. S. States during 1928. VSP(0)

Value and Investigation of Raw Materials and Products of the Steel Industry. (Wertung und Erforschung der Rohstoffe und Schlüsselerzeugnisse für die Eisenhütten-Industrie.) A. Wagner. *Stahl und Eisen*, Vol. 5, May 15, 1930, pages 655–668.

Paper before the Annual Meeting of the Verein deutscher Eisenhüttenleute, May 17, 1930, Düsseldorf. The article outlines the present state of our knowledge on the known and still unknown properties of the most important raw materials, as for instance, coal, coke and ore on the one hand and pig iron as the chief product on the other hand. The necessity of further research is stressed. It is simple to judge the quality of a coal when used as powdered coal. Nearly all types of coal, except those with unsuitable properties, are fit in powdered state. The relations between chemical composition and fitness for coke are complicated. Final facts on this relation are not known yet, though the last few years' investigations have revealed many facts. Laboratory tests on coking properties of coal are not always useful in judging coals for coke. The actual test in blast furnace and cupola is better. The physical properties have to be taken in account. Pig iron cannot be judged by the chemical composition alone. GN(0)

PROPERTIES OF METALS (1)

A Note on Metallic Magnesium. W. R. D. Jones. *Journal Institute of Metals*, Advance Copy 523 (1930), 4 pages; *Engineering*, Vol. 129, Mar. 21, 1930, page 394.

The author has made a comparison of redistilled magnesium of 99.99% purity and ordinary commercial magnesium. Comparison tests of physical properties are given and the superiority of the purer product is brought out. AEH & LM(1)

Vanadium. *Vancoram Review*, Vol. 1, Oct. 1929, pages 7–9.

A brief history of the discovery of vanadium, its metallurgical and chemical applications. (1)

The Emission of Positive Ions from Metals. H. B. Wahlin. *Physical Review*, Vol. 34, July 1, 1929, page 164.

During the investigation of the critical potentials in metallic vapors it was observed that considerable positive ion currents were obtained when the metals were heated. A study of these currents by positive ray analysis has shown that iron, nickel, copper, zirconium, platinum and palladium give alkaline ions which persist for a considerable time when the metals are heated. The persistence was most marked in the case of iron. (1)

The Solubility of Zinc in Sulphuric Acid. F. W. Harris. (Evans-Wallower Zinc Co.) *Preprint* 57–31, *American Electrochemical Society*, May 29–31, 1930, page 355–366.

An apparatus is described whereby the rate of evolution of hydrogen from zinc in acids can be readily measured. A cone-shaped cast specimen is used, which, after treating in sodium hydroxide to remove superficial metal, is corroded in 20% sulphuric acid, until a constant surface and a constant rate of gas evolution are attained. The specimen is then tested in dilute sulphuric acid, and the rate of dissolution is expressed in terms of cubic centimeters of hydrogen evolved per minute. The effect of minute additions of impurities is measured, using 99.992% zinc as a base. Of the impurities tested, copper, iron and antimony have the most pronounced effect, in the order named. Cadmium and lead have only a small effect, and aluminum is practically inert. When very small quantities of gelatin are added to the acid, gas evolution is markedly inhibited. Sodium silicate, on the other hand, has only a slightly inhibiting effect. (1)

Progress in the Production and Use of Tantalum. G. W. Sears. *Technical Publication*, No. 279, *American Institute of Mining & Metallurgical Engineers*, 1930.

See *Metals & Alloys*, April 1930, Vol. 1, page 471. (1)

Beryllium—A Metal of the Future. *Machinery*, Mar. 1930, Vol. 36, page 529.

Abstract of a paper read before the Cleveland aeronautic meeting of the Society of Automotive Engineers. Beryllium has a specific gravity of 1.64, its strength is high, its modulus of elasticity is about the same as that of steel, thermal expansion coefficient and melting point about that of cast iron, and it has a high resistance to corrosion. It lacks ductility. It occurs in much larger quantities than has previously been believed. The ore can now be bought in carload lots at from $50 to $60 per ton. A large order might be expected to bring the price down to $20 to $30 per ton. RHP(1)

A Chart of Physical Properties of Spring Materials. *The Mainspring*, May 1930, Vol. 3, 4 pages.

A very interesting table of the physical properties of many commonly used spring materials is given. It is in two sections, one devoted to steels and the other to non-ferrous metals. MLM(1)

Silicon. H. W. Gillett. *Metals & Alloys*, May 1930, Vol. 1, page 491.

An editorial. Silicon has recently become a valuable corrosion resistant alloying element. An argument is present for further investigation since it should yield an abundant supply of an exceedingly cheap mineral. ESC(1)

On the Polymorphy of Zinc. (Uber die Polymorphie dés Zinks). W. Guertler & L. Anastasiadis. *Zeitschrift für Metallkunde*, October 1929, Vol. 21, page 338.

Zinc of 99.999% purity was thermally investigated with a Saladin apparatus with a double mirror galvanometer. The object was to throw light upon the allotropy of this metal. The authors who did not find any critical point, conclude that the various transition points previously found by numerous investigators at various temperatures must be ascribed to the impure zinc employed. This general conclusion is substantiated from a theoretical viewpoint. EF(1)

Cadmium. His Majesty's Stationery Office, 1929, 23 pages.

The first half of this pamphlet is devoted to general information about Cd —its extraction, alloys, cadmium pigments and uses of cadmium compounds in industry. The second half reviews the production of cadmium in different parts of the world and includes a table of references to technical literature. MLM(1)

Beryllium (Il Berillio). M. Rossini. *La Metallurgia Italiana*, February 1930, Vol. 22, pages 287–297.

Lengthy abstract of the data reported by the Siemens & Halske laboratories. See *Metals & Alloys*, Aug. 1929, Vol. 1, pages 71–72. No original data. HWG(1)

Absolute Cohesion in Metals. Disruptive Negative Pressures and Critical Disruptive Volumes. Robert Franklin Mehl. *Journal American Chemical Society*, Vol. 52, Feb. 1930, pages 534–540.

It is pointed out that Richards' equation of state for solids can be used in the calculation of the negative pressures necessary for the disruption of metallic lattices and of the critical volumes at which the disruption should take place, a calculation hitherto not performed. Disruptive negative pressures and critical disruptive volumes are calculated for the twelve cubic metals for which Richards has given the constants in his equation of state. The values obtained suggest that the tensile strengths of metals and alloys have by no means reached their maximum possible values. MEH(1)

The Potential of Lead-Lead Ion. Merle Randall & Jessie Y. Cann. *Journal American Chemical Society*, Vol. 52, Feb. 1930, pages 589–592.

The potential of the lead–lead ion electrode has been determined by measurements of the lead amalgam–lead nitrate electrode, combined through flowing junctions, with silver–silver choride electrode. The standard potential of lead ion is found to be 0.1203 volt, and the free energy of formation to be −5551 calories at 25°. MEH(1)

Beryllium (Il Berillio). D. Migliacci. *Giornale di chimica industriale ed applicata*, Jan. and Feb., 1930, Vol. 12, pages 23–27, 83–87.

Résumé of the literature of beryllium, containing 109 references. The ores, the separation of the oxide from the ore, of metal from the oxide, the properties of the metal and of its alloys are discussed on the basis of published information, largely from the publications of the Siemens & Halske laboratories. See *Metals & Alloys*, Aug. 1929, Vol. 1, pages 71–72. Special comment is made on the high modulus of elasticity of the metal. No original data is given. HWG(1)

Meeting of the Aluminum Committee of the International Electrical Commission at Berlin, Germany, Nov. 6, 1929. (Commission Electrotechnique Internationale: Réunion du Comité de L'Aluminium à Berlin.) *Revue Générale de L'Electricité*, Jan. 4, 1930, pages 1–2.

During this meeting it was agreed that the International Standard of cold worked aluminum (that is, aluminum having a tensile strength of 15 kilograms or more per square millimeter)should be that of an aluminum bar having an electrical resistance of 2.845 microhm-centimeters at a temperature of 20° C., and that the specifications proposed by the Committee will be submitted to the International Electrical Commission for approval during the 1930 meeting. AJM(1)

PROPERTIES OF NON-FERROUS ALLOYS (2)

Phosphor Bronze for Bearings. H. C. Dews. *Metallurgia*, Vol. 1, Nov. 1929, pages 21–23.

Composition and function of hard and soft constituents. Adjustment of tin and phosphor contents. Data on the properties of phosphor bronzes containing nickel. (2)

Aluminium Bronzes with Zinc, Silicon and Antimony. (L'etude des bronzes d'aluminium speciaux au zinc, au silicium et a l'antimoine.) Part I. Armel Sevault. *Revue de Metallurgie*, Vol. 27, Feb. 1930, pages 64–83.

Alloys containing 71–92% Cu, 3.55–12.8% Al and 1.0–23.5% Zn were studied by thermal analysis, determination of electric resistance, thermoelectric characteristics, hardness, density and microstructure. Aluminum bronzes containing Zn do not form any martensitic alloys in the cast state. Only one alloy (86.6 Cu, 12 Al and 1.62 Zn) produced an acicular structure probably caused by high rate of cooling. In very high Zn alloys transformation of alpha plus beta into solution of the latter occurs at 480°. Transformation into beta plus gamma occurs at 280° and 480°. Zinc appears to increase the hardness of Al bronzes. JDG(2)

Aluminum Alloys for Pressure Die Castings. S. Tour. *Proceedings American Society for Testing Materials*, Vol. 29, 1929, pages 487–505; Foundry Vol. 57, Oct. 15, 1929, pages 869–872.

Paper enumerates the properties of aluminum alloys used for die casting, and summarizes, in general terms, the effects of addition elements: nickel, iron, zinc, etc., on mechanical strength, fluidity, etc. The consensus of opinion is that the addition of nickel is an advantage, tending to increase the mechanical strength of the alloys, both at normal and at elevated temperature, and to reduce run marks, etc., in the finished castings. The presence of nickel also appears to minimize the corrosive attack of the alloys on molds, dies, etc. Aluminium alloys containing a small amount of nickel also show improved polishing qualities and higher light reflectivity. (2)

Colour of Alloys. Masawo Kuroda. *Scientific Paper* No. 231, *Institute of Physical and Chemical Research, Tokyo*, Vol. 12, March 15, 1930, pages 308-320.

Considers four binary alloys, Cu-Bi, Cu-Ag, Cu-Ni and Cu-Zn, as representative types having visible color. Attempts to reveal relation between color and composition of alloys. Eutectic alloys and alloys of agglomerate structure have reflective power proportional to their composition. Solid solution does not follow dilution theory of color in liquid solution, but shows color different from each of the components. Gives curves showing absorption of light at multiple reflections on the surfaces of the four series of alloys studied. LM(2)

Some Alloys of Aluminium. G. M. Dyson. *Chemical Age*, Vol. 21, July 6, 1929, *Metallurgical Supplement*, pages 1–2.

In the course or a review of the properties and applications of some of the more important aluminum alloys, attention is drawn to the improvement effected in the mechanical properties of these materials by the addition of small percentages of nickel. Modified alloys of this type are being increasingly used for the pistons of internal combustion engines; typical compositions are given as (1) aluminum 95, nickel 5%; (2) aluminum 95, copper 2.5, nickel 1.5, magnesium 1%; (3) aluminum 92.5, copper 4, nickel 2, magnesium 1.5%. ("Y" alloy) and (4) aluminum 92.5, copper 5, nickel 0.5, zinc 1.5%. (2)

Die Casting. A. H. Mundey. *Metal Industry*, London, Jan. 9, 1930, Vol. 36, pages 33–34. (Concluded.)

As regards aluminum alloys, author claims that satisfactory castings can be produced with 12% silicon alloys. Such alloys are less liable to hot shortness, are easier to cast, have good tensile strength and are more resistant to corrosion. Addition of sodium and some of its compounds to aluminum-silicon alloys when molten caused a marked change in the crystalline structure of the metal. Magnesium alloys have a low density and a high specific heat. These alloys can be produced by pressure die casting. Contains tables giving chemical and mechanical properties of the various die casting alloys. VSP(2)

Data for Designing Sheet-Aluminum Parts. K. GEORGE SELANDER. *Machinery*, April 1930, Vol. 36, pages 608–610

Presents several tables of data regarding the working, bending, punching and shearing of the aluminum alloy, 51-S, made by the Aluminum Company of America. RHP (2)

Aluminium and Its Alloys. A. G. C. GWYER. *Metal Industry*, London, Sept. 20, 1929, Vol. 35, pages 275–278; Oct. 4, 1929, pages 325–326.

Eighth lecture of the Institute of Metals. Aluminum alloys are covered by the following broad classification. Alloys with copper; alloys with copper and zinc; alloys with silicon, without or with copper. Aluminum and iron form very complex compounds if iron content is over 40%. Heat treatment of aluminum alloys is discussed. Precipitation theory and age-hardening alloys are dealt with. X-ray spectrography of aluminum showed that it had the face-centered type of cubic lattice (parameter 4.05 A. U.). VSP (2)

Mechanical Properties of Duralumin in Relation to Deformation during the Aging Process. *Transactions of the Central Aero-Hydrodynamical Institute* No. 39; U. S. S. R. Scientific Technical Department of the Supreme Council of National Economy No. 293, 1929, 116 pages (in Russian).

The investigation determined the physical properties of duralumin after the aging process, in relation to the change in shape produced by tension in different moments of the aging process; the relation of aging process to the deforming process in different times. The samples consisted of duralumin sheets and round rods. (2)

Thermal Conductivity of Light Alloys for Pistons. C. GRARD & J. VILLEY. *Iron Age*, Oct. 17, 1929, Vol. 124, page 1036.

Abstract translation of a paper presented before Academie des Sciences. States that thermal conductivity of aluminum-copper decreases with increase of copper. The effect in magnesium-copper series is opposite. There is little difference in the two systems when copper is 7½% or more. Several of these alloys, and especially the aluminum alloy known as alpax, are used in airplane engine construction. VSP (2)

Chrome-Nickel Stainless Alloys. T. HOLLAND NELSON. *Iron Age* Oct. 3, 1929, Vol. 124, pages 887–890.

Considers briefly earlier investigations on these alloys. Discusses the chemical and physical properties of the alloys and their various applications, especially in the chemical field. Methods of forging, annealing, pickling and casting. Concludes that chrome-nickel alloys have opened up a wider field of applications for corrosion resistant alloys and that due regard should be paid to chromium content of any alloy which is used to combat corrosion. VSP (2)

Relation between Structure of Hard-Drawn Copper and Its Conductivity R. W. DRIER & C. T. EDDY. *Rolling Mill Journal*, Oct. 1929, Vol. 1, pages 433–434.

Abstract of paper read before the American Institute of Mining and Metallurgical Engineers, Sept. 1929. See *Metals & Alloys*, March 1930, page 425, "Correlation of the Ultimate Structure of Hard-Drawn Copper Wire with Electrical Conductivity." MS(2)

Static Properties of Ultra-Light (Magnesium) Alloys. (Proprieta statiche delle leghe ultraleggere.) N. PARRAVANO & G. GUZZONI. *La Metallurgia Italiana*, March 1930, Vol. 22, pages 367–402.

The ordinary tensile properties of several wrought magnesium alloys compared with duralumin, and of 2 cast magnesium alloys compared with silumin, are given. The important part of the article deals with short time proportional limit tests and long time continued loading "flow" tests, both made with modified Martens-type extensometers. The flow tests were made at room temperature. Details of the loading devices, the extensometer and the difficulties due to thermal expansion, unless the temperature was closely controlled, are given in detail. The full tabular data for the observations on flow, as well as for the proportional limit tests, are recorded and plotted in the paper. The flow tests were carried on, unless continuous stretch took place, to around 150 or 200 hours. Failure to show any stretch (after that due to initial flow, followed by strain hardening and cessation of flow) beyond the limits of reproducibility of the observations (around 0.0003% elongation) for 30 to 60 hours was taken as indication that no further flow would occur. The loads chosen for the flow tests were varied by quite large increments, for example, one alloy showed continuous stretch at 22,800 lbs./in.², and the next lowest load tried was 20,000 lbs./in.² The load taken as the "limit of viscosity," the highest that will not result in continuous flow, may therefore not be particularly close to the exact value. The results are probably at least intercomparable. The essential data follow:

Composition	Al	Mn	Si	Fe	Cu	Zn	Mg
A	2.22	0.36	0.02	0.03	3.98	..	Bal.
B	4.13	0.75	0.08	tr.	0.07	..	Bal.
C	0.21	tr.	0.08	0.04	tr.	4.22	Bal.
D	6.67	0.19	0.04	0.03	0.02	0.50	Bal.
E	5.72	tr.	0.19	0.03	0.12	..	Bal.
F	10.63	0.71	0.19	0.03	0.04	tr.	Bal.
FH	10.08	0.65	0.19	tr.	0.04	..	Bal.
FW	10.75	0.17	0.09	0.03	..	..	Bal.
G	8.73	0.36	0.03	0.02	0.08	..	Bal.
H	3.26	0.50	0.20	tr.	0.06	0.40	Bal.
Duralumin	Bal.	0.69	0.35	0.43	3.94	..	0.56
Silumin*	Bal.	0.04	12.42	0.47	0.02	..	tr.
IF*	4.36	0.35	0.15	0.06	0.08	3.56	Bal.
IG*	6.59	0.24	0.25	0.04	0.16	3.21	Bal.

* Cast.

Alloy	"Limit of viscosity" or creep limit	Proportional limit for 0.001% perm. set	Tensile strength	Elong. %	Red. Area %	Brinell approx.
	lbs./in.²	lbs./in.²	lbs./in.²			
A	6,400	3,700	32,750	12.7	17.6	60
B	10,600	9,400	....	..	....	...
C	10,000	10,000	37,500	11.5	24.3	55
D	20,600	11,500	46,500	15.5	31.1	77
E	15,000	13,900	43,500	6.7	26.7	70
F	20,000	13,000	49,000	11.0	19.6	85
FH	22,800	16,100	57,500	1.9	4.7	105
FW	22,800	14,300	52,000	10.7	18.5	75
G	....	15,100	61,500	5.0	12.1	105
H	10,600	8,800	40,000	10.5	36.3	75
Duralumin	35,000	21,800	61,000	16.5	34.5	115
Silumin	6,500	3,300	25,500	6.8	9.9	55
IF	6,000	2,400	24,000	4.4	6.1	59
IG	6,500	4,200	18,500	1.3	....	64

Taking the specific gravity of all the magnesium alloys as 1.8, of silumin as 2.6 and duralumin as 2.8, the specific creep limits show no appreciable superiority for even the best magnesium alloys over duralumin, but the cast alloys show some superiority over silumin. HWG(2)

"Silveroid" a New Alloy. HARRY CAMPBELL. *American Metal Market*, April 26, 1930, Vol. 37, page 3.

Silveroid contains: Cu 54%, Ni 45% and Mn 1%. The metal is white throughout, does not change in appearance through wear, does not tarnish and ordinarily requires no cleaning or polishing. It is being employed in making articles such as tea-sets, etc., ordinarily nickel-plated or silver-plated. It is claimed to be 2½ times stronger than ordinary nickel plated ware. WHB(2)

Ultralumin. FRANZ BOLLENRATH. *Luftfahrtforschung*, Dec. 12, 1929, Vol. 6, pages 18–32.

Ultralumin is a new light-metal produced by the Ultralumin-Le chtmetall Aktiengesellschaft and has the following composition: Cu 4.7%, Mn 0.75%, Ni 0.2%, Th and Cer traces; the remainder is commercial aluminum. It has a melting point of 645° C.; it can be forged at 460° (to 480°). Its heat expansion coefficient is 0.000022, temperature resistance coefficient 0.00218 and electrical conductivity is 20–23 m./Ohm./mm.² The modulus of elasticity is 6900 to 7300 kg./mm.² A kneading treatment by forging or rolling will refine it; the necessary heat treatment is described. The physical tests and testing methods are described, and illustrated by numerous tables and diagrams for different types of this light-metal. The results show that Ultralumin is fully equivalent to other similar alloys. HA(2)

On the Problem of the Critical Dispersion of Lautal. (Zur Frage der kritischen Dispersion von Lautal.) DR. H. BOHNER. *Zeitschrift für Metallkunde*, May 1929, Vol. 21, pages 160–165.

After critically reviewing former work done on this subject, the author presents his own investigations on the critical dispersion which was studied by means of measurements of tensile strength and electric conductivity which indicate remarkable relationship to hardening temperature and time. The writer draws the following conclusions of practical importance: (1) Lautal (4.25% Cu, 2.221% Si, 0.46% Fe and remainder Al) should not be permanently exposed to temperatures exceeding 120° C. The electrical conductivity rises rapidly but the tensile strength falls off appreciably. The critical temperature limit seems to be at about 100° C. (2) In improvable Al alloys, which are artificially age hardened, several conductivity values correspond to each tensile strength value. The magnitude of the conductivity values depends on hardening temperature and hardening time. The significance of this relationship in production work is indicated. EF(2)

PROPERTIES OF FERROUS ALLOYS (3)

Tungsten Steels. *Iron & Coal Trades Review*, Jan. 3, 1930, Vol. 120, page 13; *Foundry Trade Journal*, Jan. 9, 1930, Vol. 42, page 26.

Abstract of an article in the *Archiv für das Eisenhüttenwesen*. See *Metals & Alloys*, May 1930, page 521, "Investigations on Tungsten Steels." RHP & VSP(3)

Determination of Specific Volume of Iron, Nickel and Iron Alloys in the Liquid State. (Bestimmung des spezifischen Volumens von Eisen, Nickel und Eisenlegierungen im geschmolzenen Zustand.) C. BENEDICKS, N. ERICSSON & G. ERICSON. *Archiv für Eisenhüttenwesen*, Jan. 1930, Vol. 3, pages 473–486; *Stahl und Eisen*, Vol. 50, Mar. 1930; pages 332–334; *Metallurgist*, Feb. 1930, pages 29–30.

The article corresponds to the publication in *Jernkontorets Annaler*, Sept. 1929, pages 423–490. See *Metals & Alloys*, Feb. 1930, Vol. 1, page 383. GN(3)

Weather Proof Iron. *Industrial Bulletin, Arthur D. Little Co.* Dec. 1929, page 3.

Describes a typical alloy containing 18% chromium, 8% nickel and up to 0.20% carbon which is weather proof. Its properties are given and many of the uses to which it has been put. MLM(3)

Cast Iron for Fuel Economizers. O. KUBALEK. *Foundry Trade Journal*, Jan. 16, 1930, Vol. 42, page 52.

Abstract of paper read before the Institute of Fuel. Gives brief historical review of fuel economizers. Cast iron is said to be the traditional material for fuel economizers. Cast iron owes its continued existence to the fact that it is capable of resisting corrosion. Gives B.E.S.A. specifications for cast iron. Compares present-day product with cast irons used twenty years ago. VSP(3)

A Stainless Alloy. T. HOLLAND NELSON. *Iron & Coal Trades Review*, Jan. 3, 1930, Vol. 120, page 7.

Abstract of an article from *Iron Age*. An alloy of 18% chromium, 8% nickel and the remainder iron, may be easily worked into articles of intricate design. It can be forged or rolled at a temperature of from 2200° F. down to about 1700° F. without difficulty. Being an austenitic alloy, the softest condition is obtained by heating to a temperature of from 1900–2100° F. and cooling as rapidly as possible. Sand blasting to accelerate pickling cannot be used as particles of sand become imbedded in the metal. Pickling is done in 20 to 40% hydrochloric acid, washed, then immersed in 10 to 20% nitric acid, and washed. Good pickling of the castings is very difficult. For best results the acids should be hot. This metal contracts greatly on solidification. RHP(3)

Structural Steel Heat Treated. P. F. LEE & H. A. SCHADE. *Iron Age*, Feb. 13, 1930, Vol. 125, pages 510–514; *Iron & Coal Trades Review*, Mar. 28, 1930, Vol. 120, page 527.

Gives results of investigation to determine what physical properties could be obtained by heat treatment of hot rolled low carbon steel, similar to S.A.E. 1020 steel. Forty-five samples were examined. Specimens were analyzed for carbon and manganese. Carbon ranged from 0.12 to 0.32%, and manganese from 0.34–0.77%. Average quenching temperature for maximum hardness was 1600° F. Test bars conformed to the requirements of A.S.T.M. for structural steels, except that width of diminished section was 1 in. instead 1½ in. For successful heat treatment a manganese content of at least 0.60% is essential. Gives detailed study of steel of special analysis. Results shows that the elastic ratio of steel is increased by heat treatment. Welding on this steel should be done before heat treatment; heat treatment depends on physical properties desired and increase in tensile strength is accomplished by decrease in ductility. Contains many tables. RHP + VSP(3)

Gray Iron Possesses Valuable Engineering Properties. Pt. II. *Foundry*, Mar. 1, 1930, Vol. 58, pages 107–110, 142.

Cupola irons are made with tensile strength of from 50,000–65,000 lbs./in.² Properties of gray iron are influenced by change in cooling rate to a greater degree than are those of most metals. Tensile strength values of gray cast iron are taken from separately cast test bars. Best wearing irons are those of pearlitic matrix and rather low in carbon. Up to 800° F. good gray irons lose little if any strength as measured on short time tests. At 1000° F. they show a tendency toward graphitization. At 1200° F. graphitization proceeds steadily, while over 1300° F. it is quite rapid. Gray iron is reliable and modern material of construction. It is a series of alloys, and within this series are found materials which vary widely in mechanical properties. Any grade of gray iron is microscopically a heterogeneous alloy. It is composed of various amounts of 4 components, namely, graphite, pearlite, ferrite and steadite. Gives number of illustrations. VSP(3)

High Test Cast Iron. O. SMALLEY. *Foundry Trade Journal*, Jan. 9, 1930, Vol. 42, pages 25–26.

Paper presented at the annual meeting of the American Foundrymen's Association. High test cast irons are used on account of the latent and undeveloped possibilities of cast iron, the unreliability of cast iron and the need of an iron to combat steel competition for castings, forgings and stampings. Cupola melted high test cast iron made by various processes have following features in common: Use of high % of steel or low silicon content; lowered total carbon and phosphorus; superheating in melting; and control of graphitization. Contains tables giving physical properties of the high test cast irons. VSP(3)

Properties of Cast Silicon Steel. (Ueber die Eigenschaften von silizium legiertem Stahl in Form von Stahlguss.) E. H. SCHULZ & F. BONSMANN. *Stahl und Eisen*, Feb. 6, 1930, Vol. 50, pages 161–168.

Abstract from *Mitteilungen aus dem Forschungsinstitut der Vereinigten Stahlwerke A. G.* The investigation, carried on with 6 cast silicon steels, compares the physical properties of these steels with unalloyed cast steel. The heats were melted in an 80-ton open hearth furnace, ferro-silicon added in the ladle. The 6 heats contain carbon 0.14–18%, Mn 0.73–1.22%, Si 0.73–1.3%. The plain carbon cast steel contained 0.39% C, 0.81% Mn, 0.45% Si. Two of the heats contained Ti 0.13%, and 0.30% Cu, respectively. The greatest advantage of silicon cast steel is a higher degree of plastic deformation. Elongation, reduction of area and notch toughness are much more favorable than with carbon cast steel of the same tensile strength. Referring the tensile properties to the same yield point the values for elongation and reduction of area are about 60% higher, the notch toughness about 80% higher than for carbon cast steel. The influence of annealing temperature on tensile strength and notch toughness after various preheatments was tested between −80° to +500° C. Annealing temperatures to obtain the best physical properties are 100–150° C. higher than for plain carbon steel. Physical properties plotted against temperature show for silicon and carbon steels similar curves, but silicon has better properties for all temperatures. Endurance impact tests and alternating bending tests also show the supremacy of silicon cast steel. Silicon steels tend more to corrosion which can be very much decreased by adding 0.3% Cu, so that this steel is less corrosive than plain carbon steel. GN(3)

Der Zusammenhang zwischen der Chemischen Zusammensetzung von Chrom-Eisen und Vanadium-Eisen Legierungen mit einigen physikalischen Eigenschaften. K. RUF. *Verlag Chemie*, Berlin, 1929. Paper 6×9¼ inches, 23 pages, 13 figs., 8 tables.

Ruf's investigation (published abbreviated in *Zeitschrift für Elektrochemie*, December 1928, page 813, and following), carried out to obtain his Doctor's degree at the Technische Hochschule Danzig, will interest the metallurgist as well as the electrical engineer. The former from the pure scientific standpoint in so far as it is a contribution to our knowledge of a group of physical properties of iron combined with 2 elements which will be of increasing importance to the alloy-steel manufacturer and the latter will be interested in this publication in his quest for iron alloys suited for electrical resistance material. The investigation covers measurements on specific resistance, temperature coefficient of specific resistance, electromotive force, specific gravity and coefficient of heat expansion. GN(3)

Mass and Skin Effects in Cast Iron. H. W. SWIFT. *Foundry Trade Journal*, Jan. 30, 1930, Vol. 42, pages 79–80; Feb. 6, 1930, pages 106, 108.

Discusses the effect on the mechanical properties of cast iron of transverse section of the bar as cast, and machining to various depths below the skin. B. E. S. A. specifications for grey iron.

Casting Thickness	Key	Test bar cast. dia.	Modulus of Rupture Grade A	Modulus of Rupture Grade C	Tensile Bar turned dia.	Ten. Str. Grade A	Ten. Str. Grade C
<¾ in.	S	0.875	24.2	19.6	0.564	12	10
¾ in.–2 in.	M	1.2	23.1	18.9	0.798	11	9
72 in.	L	2.2	19.2	17.2	1.785	10	9

Results of tests showed that the tensile strength varied from 14 tons per sq. in. for ½″ bar to about 6½ tons for 3″ bar. Comprehensive tests on rough bars showed 70 tons per sq. in. for ½″ bar to 36 tons for 3″ bar. Tabulates results of abrasion tests on bars ½, 1, 2 and 3″. Microscopic examinations shows that iron consists of pearlite, silico-ferrite and the phosphoric eutectic. Tensile weakness of iron is due to free carbon. As skin is removed a continual diminution occurs in the crushing strength so long as skin-effect is present, and hardness becomes less. Tensile strength improves at first and then falls after turning and, there is a skin "hardness" to machining. There is no sign of degraphitization below the surface, but actual skin degraphitization does occur. VSP(3)

High-Duty Cast Irons. A. E. MCRAE SMITH. *Foundry Trade Journal*, Jan. 23, 1930, Vol. 42, pages 59–60; Jan. 30, 1930, pages 83–87; Feb. 6, 1930, pages 99–100.

Includes discussion. Paper presented to the Sheffield and London sections of the Institute of British Foundrymen. Concerned chiefly with high-test irons which can be produced directly from the cupola without the use of refining, superheating and heat treating processes. Metallic raw materials for cupola-melted gray cast irons are as follows: (1) Pig Iron; (2) scrap cast iron; (3) foundry scrap or surplus melt; (4) steel scrap; and (5) ferro alloys or alloying elements. In the manufacture of light castings the determining factors are: exactness of form, freedom from obvious defects and easy machinability. Medium strength castings are made from the cheapest phosphoric irons. High grade castings are made by different processes, but many are cupola-melted mixtures high in steel scrap and low in phosphorus. They are produced with or without the application of desulphurization processes, and carbon control being the main feature. Double process irons are first melted in a cupola or air furnace and transferred in a molten state to an electric furnace. Steel mix irons are divided into irons with total carbon of 2.8–3.3%, silicon 1.6–2.5 or even 3.0%; those with total carbon over 3.3% and silicon from under 1% upward; straight steel mix irons with over 40% raw steel, with total carbon 3.0% and under, and silicon less than 1.4%. High duty cast iron should be equally high tensile strength through large range of sections and masses. Describes the Poumay cupola. Chief alloying elements used in making alloy cast irons are nickel, chromium, copper and manganese. Tabulates results of test of the various irons. VSP(3)

New Nickel-Iron Alloy. *Electrician*, March 14, 1930, Vol. 104, pages 330–331.

Permalloy "C" exhibits magnetic and manufacturing properties considerably better than those of Permalloy "A" which it now replaces. It is, from the viewpoint of magnetic properties, the softest material available, and possesses the advantages of having high resistivity and of requiring a simpler form of heat treatment than the earlier alloys. Data are tabulated for Permalloy "C" and for silicon steel. It is found that materials with the highest initial permeability will have the steepest permeability-frequency curve, other factors being equal, and the higher the resistivity, the lower the rate of decrease of permeability with frequency. For best results, it is well to heat treat the material after the component has attained its final shape. Permalloy "C" requires but a single simple annealing process. The method of manufacture is outlined and several types of instruments made from it are noted. WHB (3)

Compares Properties of Various Alloy Steel Castings. DAVID ZUEGE. *Foundry*, Jan. 1, 1930, Vol. 58, pages 100–103; Jan. 15, 1930, pages 71–74. *Foundry Trade Journal*, Vol. 41, Sept. 5, 1929, pages 167–168, 178.

An abstract of paper presented at the Chicago convention of the American Foundrymen's Association. Confined to steels of high physical properties. Alloying elements used are chromium, nickel, manganese, vanadium and molybdenum or combinations of the above. Chromium steels have a fine structure, producing higher static strength than straight carbon steels. Nickel dissolves in iron in all proportions. Manganese forms a complex iron manganese carbide and a solid solution of manganese and iron. Vanadium is a powerful deoxidizing agent and it is believed that the beneficial effects obtained through its use are due largely to its elimination of impurities. It also forms complex carbides. Contains several tables giving the physical properties of vanadium and manganese steels. Compares also carbon and manganese cast steel, and manganese carbon steel, oil quenched and drawn. Discusses the physical characteristics of various alloy steels for casting purposes. Chromium, when in combination with nickel, imparts marked hardening properties to the steel. Alloy castings which must be heat treated individually contain an appreciable amount of chromium either alone or in combination with other alloying elements. Contains tables in which the various steels are compared as to their physical properties. Micrographs accompanying the data show the effect of alloys on the structure of the steels. VSP(3)

CORROSION, EROSION, OXIDATION, PASSIVITY & PROTECTION OF METALS & ALLOYS (4)

Composition and Laboratory Testing of Paints for Boiler Interiors. (Wesen und laboratoriumsmässige Prüfung von Kesselinnenanstrichmitteln.) HOFER. *Veröffentlichungen des Zentral-Verbandes der Preussischen Dampfkessel-Ueberwachungs-Vereine*, 1929, Vol. VI, pages 85–95.

Boilers using water which is not treated can be painted on the inside to facilitate the removal of scale. The 41 commercial paints examined consist of 3 groups: I Solutions of bituminous materials in hydrocarbons, and tar and oil residues, sometimes with the addition of graphite, II Suspensions of graphite in linseed oil, mineral oil and water containing organic colloids, and III Suspensions of metallic oxides in linseed oil. Typical analyses of each group are given, but this is not sufficient to determine their usefulness. Elasticity of the film is tested by bending thin sheets coated with paint arounds rods of various diameters. Paints in group I and linseed oil suspensions of group II withstood this test very well, but not the water suspensions of graphite. Stainless Steel test sheets coated with paint were weighed and hung in boiling water twice for 10 hours and loss in weight determined. In tests using water containing soda the linseed oil paints saponify and flake off. Precautions are given for applying paints with low flash points. Tests show that the heat transfer is not hindered by relatively thin coats of paint. CEM(4)

Some Recent Developments in Protective Coatings for Aluminum and Its Alloys. H. SUTTON. *Metal Industry*, London, Nov. 1, 1929, Vol. 35, pages 411–414, 424; *Brass World*, Vol. 25, Dec. 1929, pages 287–289; *Journal Electroplaters' & Depositors' Technical Society*, Vol. 5(1929) pages 1–8.

Includes discussion. Abstract of paper presented before the Electroplaters' and Depositors' Technical Society. Gives a survey of a few recent developments in the production of protective coatings on metals. Anodic oxidation process consists in making article to be treated the anode in a bath of 3% aqueous chromic acid. It can be applied to aluminum, duraluminum and most aluminum alloys. Other processes described are the Jirotka and Stafford O'Brien. VSP(4)

Corrosion of Rabbles in Zinc Roasting Furnaces. J. NEILL GREENWOOD & A. J. ROENFELDT. *Engineering & Mining Journal*, Nov. 30, 1929, Vol. 128, pages 851–852.

Alloys high in chromium but containing no nickel have been found best in the barrier roasting furnaces at the Electrolytic Zinc Co. plant at Port Pirie, South Australia. The best alloy for corrosion resistance in the furnaces contains: carbon 1½–3%, chromium 26–27% and silicon 0.5–1.0%. The presence of galena in the concentrate is regarded as the cause of the corrosion. Therefore any improvement in ore-dressing will be reflected in longer rabble life. WHB(4)

Problems and Progress in the Protection of Underground Pipe Lines Against Corrosion. GORDON N. SCOTT. Paper at fall meeting, Southwestern district, American Petroleum Institute, Galveston, Texas, Sept. 5–6, 1929. *Oil & Gas Journal*, Sept. 12, 1929, Vol. 28, pages 37, 157–158; *Petroleum Engineer*, Oct. 1929, pages 164–166; *Oil Field Engineering*, Oct. 1, 1929, Vol. 6, pages 14–15.

The relative merits of laboratory studies, field tests and field inspection of coatings are discussed. Pipe line protection is shown to be an economic problem and method of solution is outlined. (4)

Corrosion of Underground Steel Structures and Its Prevention. ROBERT E. WILSON. *Journal Western Society of Engineers*, Oct. 1929, Vol. 34, pages 578–595.

An explanation is given of the theory of what takes place when iron is in contact with various chemical combinations and shows means that have been most successful in protecting pipe lines of oil companies. Two active impurities are likely to be present in crude oil, H_2S and water, which in contact with the pipe are liable to cause rather severe, yet localized, corrosive attack on the inside of the pipe. Special attention is paid to the soil corrosion of the outside of the pipes. Three essential factors are involved: the effect of the kind of metal, the effect of the soil and the effect of protective coatings. Causes of coating failures are: chemical or physical, due to changes in the material itself; and mechanical failures due to improper handling or other things not directly connected with the coating. Some coatings are slowly soluble in oil, possibly present as a result of leakage at the joints. An unbroken coating is important, also the kind of bed in which the pipe is laid. Wrapping of the coated pipe with asbestos paper impregnated with asphalt apparently gives the best results. Another surface layer of asphalt is applied to protect the fabric and give a smooth coating. A discussion is included. WHB(4)

Electrochemical Protection of the Light Aluminum Alloys to Corrosion by Means of Zinc. G. W. AKIMOFF. *Transactions of the Central Aero-Hydrodynamical Institute* No. 46; U. S. S. R. Scientific-Technical Department of the Supreme Council of National Economy No. 316, 1929, 20 pages (in Russian).

Tests made in sea water show that duralumin in contact with zinc is not affected. Under actual conditions the protective action of zinc extends over relatively large areas. Bars (1.8 and 4 meters long) with a zinc plate attached at one end, show no signs of corrosion anywhere over their length after 5 days in sea water. A theory is proposed for the protection of aluminum by zinc, which is confirmed by laboratory tests. A practical application of the results is proposed for the protection of aluminum alloys by zinc: (1) by zinc protectors; (2) by zinc coatings; (3) by paints containing powdered aluminum. (4)

Corrosion of Various Alloys in Combusted Coal-Gas Condensate. W. E. DENNISON. *Foundry Trade Journal*, Sept. 12, 1929, Vol. 41, pages 189–190.

Gives results of tests conducted with various metals and alloys immersed in coal-gas condensate. Results show the condensate from combustion of coal-gas is not so strongly corrosive. Ferrous metals may best be protected by means of hot galvanizing. Contains a table giving relative corrosion of various alloys in gas condensate. VSP(4)

Protective Coating for Iron and Steel. E. O. Jones. *Foundry Trade Journal*, Jan. 23, 1930, Vol. 42, page 60; *Chemical Age*, Feb. 1, 1930, Vol. 22, pages 8–9; *Engineer*, Jan. 17, 1930, Vol. 149, page 75; *Iron & Coal Trades Review*, Jan. 17, 1930, Vol. 120, page 79.

Abstract of paper read before the Institution of Mechanical Engineers (North-West branch). Corrosion might result from either direct chemical attack or electrochemical action. To keep corrosion within reasonable limits there are 3 alternative methods: Use of corrosion-resistant alloys, preliminary treatment of water and preliminary treatment of metal. Protective coatings which may be applied to iron and steel are: another metal, paints, tarry or bituminous paints, cement or concrete, vitreous enamels, oxide or phosphate films and grease or oil films. VSP:RHP:LM(4)

STRUCTURE OF METALS & ALLOYS (5)

Metallography & Macrography

The Influence of Thermal Treatment on Certain AgZn and AgCd Alloys. (Influence des traitments thermique sur certain alliages argent-zinc et argent-cadmium.) Leon Guillet & Jean Cournot. *Revue de Metallurgie*, Jan. 1930, Vol. 27, pages 1–7.

Theoretical aspects of the heat treatment of Ag-Zn and Ag-Cd alloys were investigated. Eutectic alloys selected contained: 69.8% Ag–31.2% Zn, 62.3 Ag–37.7 Zn and 50 Ag–50 Zn. Constitutional diagrams of Ag-Zn (by Carpenter and Whitney) and Ag-Cd (by Guertler) were checked by heat treatment. The revised diagrams and microstructures of the alloys are given. JDG(5a)

Equilibrium Diagrams of Chromium and Tungsten Steels. (Note sur les diagrammes d'équilibre de transformations des aciers au chrome et au tungstene. Application aux aciers rapides.) N. H. Aali. *Aciers Speciaux Métaux et Alliages*, March 1930, pages 107–109.

Discusses transformation points in high-speed steels. High-speed steels having a high tungsten content are in reality ultra-eutectoid steels, the carbides of which dissolve between 900° and 1300° C. The gamma-alpha transformation takes place at about 800° C. AJM(5a)

Structure & X-ray Analysis

Some Data on X-ray Determination of Crystalline Structure. (Sur Quelques resultats d'essais crystallographiques par rayons X.) Albert Roux & Jean Cournot. *Revue de Metallurgie*, Jan. 1930, Vol. 27, pages 8–13.

X-ray study showed that annealed 70 Ag–30 Zn alloys consist of face centered cubes with the unit cell 4.502 A. U. with some indication of the presence of 4.054 A. U. cubes. After quenching only face-centered tetragons of 4.054 A. U. were found. Quenching increases the dimensions of unit cells. Drawing produces transformation into face-centered tetragons of 4.175 A. U. unit cell and axes ratio 1.06. Annealing of 90 Cu–10 Al transforms $^2/_3$ of the metal in alpha state, leaving the rest as eutectic. Face-centered cubes of 3.637 A. U. on the side are the only ones to be visible. On quenching their lines disappear but return on the annealing together with 2 more sets. Aluminum and duralumin wires annealed at 359° for 1 hour were deformed in a special apparatus at different rates and temperatures. After the specimens cooled in the air an examination was made with X-rays on sections 1 mm. distant from the plane of fracture. A metal can remain oriented by a sufficiently fast deformation even at temperatures considerably higher than the temperatures used for annealing. For each temperature there exists a speed of deformation above which instantaneous recrystallization cannot annul the strains created by deformation. The influence of impurities on the grain growth was investigated by cold rolling electrolytic and commercial coppers as one series and 99.87 and 99.4% Al as the second. Heat treatment and X-ray examination showed that impurities decrease the grain size. JDG(5b)

Crystals and Strength of Alloys. A. Glazunow. *Foundry Trade Journal*, Sept. 12, 1929, Vol. 41, page 184.

Discussion of paper read before the International Foundry Congress on "Crystalline Grains in Castings." Crystalline grain structure of castings is of great importance. Star-shaped crystals and bearing metals. Practically all metals are crystalline in structure, and the appearance of a fracture depends upon the manner the fracture is effected. The reduction of grain-size structure by a novel means without decreasing the strength. See *Metals & Alloys*, Jan. 1930, page 340, under title "The Crystal Grains in Castings." VSP(5b)

PHYSICAL, MECHANICAL & MAGNETIC TESTING (6)

Brinell Hardness Determination. R. G. Batson & S. A. Wood. *Iron & Coal Trades Review*, Nov. 1, 1929, Vol. 119, page 673. *Times Trade & Engineering Supplement*, Oct. 26, 1929, Vol. 25, page 142.

Abstract of a paper before the British Engineering Standard Association. Discusses the testing of steel balls used for hardness determination. See *Metals & Alloys*, Feb. 1930, Vol. 1, page 383, "The Hardness of Steel Balls Used for the Determination of the Brinell Hardness Numbers of Material." RHP(6)

Test on Large Columns of Structural Alloy Steel. *Iron Age*, Nov. 14, 1929, Vol. 124, pages 1300–1302.

Discusses tests conducted by the Port of New York authorities on structural steels and other materials of construction. Physical specifications for the 3 types of steels are:

	Carbon steel	Silicon steel	Manganese steel
Tensile strength	58,000 – 68,000	80,000 – 95,000	90,000 or more
Yield Point, Min.	35,000	45,000 (a)	55,000
Reduction in area, min. (b)	42	30	30

(a) Average for each group of 10 heats = 47000 lbs/in.^{2}
(b) Section over $^3/_4$" thick may be less ductile.

For testing, 10,000,000 lb. machine at U. S. Bureau of Standards was used. Chemical composition for silicon steel is: C< 0.40%, P< 0.04%, S< 0.04% and Si between 0.20 and 0.45%. Medium manganese steel is to analyze as follows:

	Structural steel	Rivets
Carbon— Preferably not over	0.35	0.30
Maximum	0.40	0.35
Manganese—not over	1.80	1.80
Phosphorus— Acid steel not over	0.05	0.04
Basic steel not over	0.04	0.04
Sulphur—not over	0.05	0.045
Silicon	0.10–0.30	0.10–0.30

Large columns were tested to failure. The elastic limit of columns is much below the yield point of tension specimens. Material was used for the construction of the Kill van Kull bridge. VSP(6)

Modern Methods of Testing Castings. J. S. Glen Primrose. *Foundry Trade Journal*, Nov. 7, 1929, Vol. 41, page 342.

Includes discussion. Presented at joint meeting of the Sheffield and District section of the Institute of British Foundrymen and a hundred scientific societies. Discusses the various methods of testing of castings. The various methods taken up are the optical method, electro-magnetic and X-ray method of examination. VSP(6)

Magnetism and Magnetic Materials. The Basis of the Electrical Industry. T. D. Yensen. *Electric Journal*, April 1930, Vol. 27, pages 214–218.

A review with a bibliography appended. The steady improvement which electrical apparatus has enjoyed from the beginning of the industry has been due largely to the continuous improvement in magnetic materials. WHB(6)

Physical Testing Methods and Apparatus. E. A. Allcut. *Canadian Chemistry & Metallurgy*, Dec. 1929, Vol. 13, pages 329–331; *Canadian Machinery*, Jan. 9, 1930, Vol. 41, page 42.

Physical testing and types of testing machines are outlined. The development of the impact test is indicated and the need for a standard abrasive material pointed out. WHB(6)

ELECTRO-CHEMISTRY (7)

Electroplating

Electrodeposition of Iron. T. P. Thomas. *Metal Industry*, New York, Feb. 1930, Vol. 28, pages 74–75.

See *Metals & Alloys*, April 1930, Vol. 1, page 474. VSP(7a)

METALLIC COATINGS OTHER THAN ELECTROPLATING (8)

The Metals Coating Process and Foundry Practice. *Foundry Trade Journal*, Oct. 31, 1929, Vol. 41, pages 311, 314.

Discusses metal coating process by means of metal-spraying pistol. Process consists in feeding into pistol a metal or alloy in the form of wire, where contact is made with oxy-acetylene flame, which melts the wire, and by using compressed air the atomized metal is blown against surface to be coated at a velocity of about 3000 ft./sec. The pistol is known as Metallayer. Gives operating details and foundry applications of the process. VSP(8)

Metal Coatings. *Electrician* (London), Nov. 8, 1929, Vol. 103, page 560.

The possibility of applying metallic coatings of thicknesses from 0.001" upward to articles and parts of metallic or non-metallic construction is now made practicable by the pistol spraying process sponsored by Metals Coating Co., Ltd. The metal spraying tool weighs 3$^1/_2$ lbs. and manipulated by hand, or mechanically. Several electrical applications are mentioned. WHB(8)

INDUSTRIAL USES & APPLICATIONS (9)

Ten-Ton Crane Constructed from Aluminum Alloy. *Machinery*, March, 1930, Vol. 36, page 562.

Describes a crane having a span of 72 feet. It is built entirely of aluminum alloy and is estimated to be 12 tons lighter than a similar traveling crane of steel would be. With a load of 34,500 pounds a deflection of 1.09 inches was noted in the crane girders. This load was 72.5% over the rated capacity. No permanent set was noted when the load was removed. RHP(9)

Properties Required of Sheet and Strip Steel for Automobile Bodies. Joseph Winlock and George Kelley. *Metals Stampings*, Feb. 1930, Vol. 3, pages 139–142, 170; *Automotive Industries*, Feb. 15, 1930, Vol. 62, pages 220–223.

Paper read before American Society for Steel Treating, Feb. 7–8, 1930. The paper discusses the granular structure of sheets, the effects of grain size upon deep drawing properties and how grain size may be controlled in the rolling mill as well as in the drawing plant. GN + MS(9)

Dependence of Aviation on Metallurgy. J. B. Johnson. *Metals & Alloys*, April 1930, Vol. 1, pages 450–454.

Modern airplanes are largely constructed of metals on account of homogeneity, durability, permanency of volume and form, under extreme atmospheric conditions, rigidity and resiliency. Homogeneity is necessary. It is practically determined by chemical analyses and physical properties as determined by a series of tests, also surface finish, internal defects, dimensional tolerances, eccentricity and grain size are considered. Screw machine steels high in sulphur and phosphorus are not usable in airplane construction because of their failure under vibration. Chrome nickel steel, S. A. E. 3140 is general for connecting rods and crank shafts. Gears may be carburized or oil hardened steel. Careful control of composition of the non-ferrous alloys is of importance. Fuselage and wing cellule constructions are frameworks of tension and compression members. It is important that the material have a uniform modulus of elasticity for long column and a high yield point in compression for short columns. The modulus of elasticity specified is 28,000,000 lbs./in.^{2} as compared with 20,000,000 for cold drawn carbon steel tubing. A transverse test is a very satisfactory nondestructive test for determining the strength of tubing. The deflection is a function of both the modulus and the stress of the outer fibre.

	Tensile Strength	Yield Point Tens.	Yield Point Comp.
Norma lheat treated duralumin tubing	60,000	35,000	32,000
Stretched	65,000	47,000	31,000

The yield point was taken from the stress strain curve at the point where the slope was 50% greater than the modulus slope. The material was not improved for aircraft construction. Bend tests are valuable for sheets. A combination of tensile and bend test has been found preferable to any ductility test made by cupping. Torsional characteristics are closely related to tensional properties but after the relation has been determined it may safely be assumed to be the same. Aluminum and magnesium alloy forgings and castings are determined by tensile and hardness tests and visual examinations of fracture. Hardness readings are useful for determining uniformity of material. A table of S. A. E. specifications, chemical analyses, physical properties and uses for various aircraft metals is included. *Curves of stress against number of cycles stress for rupture are given to indicate that the grooved tubing is considerably weakened. This effect is accentuated in heat treated tubes drawn below 700° F.* The wire used for aircraft bolts is tested by visual examination of milled specimens etched with hydrochloric acid. Forgings and castings are etched with alkali and dipped in dilute nitric acid. Wing beams and landing gear assemblies are heat treated to yield tensile properties of 200,000 lb./in.^{2} and 5% elongation. Preservation of materials is necessary by means of protective coatings. No magnesium or aluminum base alloys are non-corrosive against salt spray. ESC(9)

Thaden All-Metal Monoplane. *Aero Digest*, May 1930, Vol. 16, page 144.
Describes the plane and gives specifications for it. MLM(9)

Barling NB-3 Metal Wing. *Aero Digest*, May 1930, Vol. 16, page 134.
Describes and illustrates an interesting design in metal wings made of duralumin sheets with the corrugations running lengthwise. Metal planes have been in use as long as eight years without any indications of general deterioration. MLM(9)

Rare Metals Essential to Industry. *Engineering & Mining Journal*, Dec. 28, 1929, Vol. 128, pages 1001–1002.
An abstract. Applications of metals and alloys of the platinum groups in industry are indicated. WHB(9)

Hardened Copper for Electrical and Chemical Equipment. W. N. Hibbard. *Iron Age*, Nov. 28, 1929, Vol. 124, page 1434.
Abstract of paper read before the International Acetylene Association. Discusses properties, uses and welding characteristics of hardened coppers known as Everdur and Tempaloy. Tempaloy when quenched above 750° C. is ductile and can be worked. Annealed Tempaloy can be forged to shape, welded with Tempaloy rod, and then age hardened to increase mechanical strength. Everdur welding rod can also be used for Tempaloy. Welded high-copper alloys find many applications in electrical industry. Everdur is much used in fabrication of heaters, coolers, condensers, evaporators and many kinds of chemical and engineering apparatus. Tabulates physical properties. VSP(9)

The Production of High-Quality Large Forgings. Lawford H. Fry. *Canadian Chemistry & Metallurgy*, Nov. 1930, Vol. 13, pages 306–309, 312; *Discussion Transactions American Society for Steel Treating*, Apr. 1930, Vol. 17, pages 594–595.
Types of forging steels and their physical properties are discussed. See *Metals & Alloys*, Jan. 1930, pages 336 and 343, "Locomotive Forgings." WHB(9)

HEAT TREATMENT (10)

Furnace Improvement Is Greatest Need in Heat Treatment. *Iron Trade Review*, Jan. 2, 1930, Vol. 86, pages 28–29.
Comments of several authorities on heat treating progress. Nitriding is one of the most notable developments. Efforts have been made to control temperatures of furnaces more accurately and to effect better regulation of heating chamber atmospheres. Tendency has been toward automatic continuous types of furnaces. MS(10)

Automatic Heat-Treating Unit. W. M. Hepburn. *Iron Age*, Nov. 14, 1929, Vol. 124, pages 1304–1306.
Describes modern heat treating unit installed for Studebaker Corporation, South Bend, Ind., for normalizing, hardening, quenching and drawing. The furnaces are fired with both gas and oil. Waste heat passes out through vent in roof, close to loading end. Used for heat treating connecting rods, steering knuckles, steering arms, etc. VSP(10)

Electric Heat Treating Produces Better Shovels at Less Cost. Wirt S. Scott. *Electric Journal*, April 1930, Vol. 27, pages 207–210.
At the Parkersburg, W. Va., plant of the Baldwin Tool Works, it has been found profitable to equip with electric heat treating furnaces. Savings have been effected in cost, the quality of product was improved, production increased and rejects reduced. Tables show: heat treating with gas furnaces, with electric furnaces, the power rate for electric furnaces and total production costs. WHB(10)

Heat Treats Stainless Steel Tubes. *Iron Age*, Oct. 31, 1929, Vol. 124, pages 1157–1160.
Discusses the development of new types of members, materials and methods of manufacture by Boulton and Paul of Norwich, England, for use in the construction of the giant airship R-101. Tubes are made from soft strips drawn through pair of dies with an electric furnace between. Gives the chemical and physical properties of the steel and describes the continuous heat treating process used. Hardness and close bend tests are carried out on each end of every section. Product is uniform. VSP(10)

Electric Heat Treatment for Aluminum. N. B. Jones. *Metal Industry*, N. Y., Sept. 1929, Vol. 27, pages 421–422.
Discusses the advantages of aluminum castings made in permanent molds over sand castings. The tensile strength is 3000–5000 lbs. greater than for sand castings. The heat treating is done exclusively in electric furnaces. Recently a new type of electric furnace has been put in operation known as the pit type furnace. The advantages claimed for this type of furnace are: economical operation, quick heating time and control of upper temperature and accurate temperature control throughout heating cycle. VSP(10)

(b) Annealing

Calculation of Furnace for Mixed Brass Annealing. R. M. Cherry. *Electrical World*, Nov. 30, 1929, Vol. 94, page 1088.
Calculations are based on an assumption that the brass is in miscellaneous size coils, bars, etc., and to be annealed in a pan type furnace. Assumed data: wt. of charge 8000 lbs.; temperature 1100° F., wt. of pans 850 lbs.; total time of proper anneal 1½ hours; from which the rate is calculated. In actual operation the economy in pounds of brass per kw.-hr. is 20–25.4. WHB(10b)

Anneals Magnetic Sheets Electrically. F. E. Finlayson. *Iron Age*, Oct. 17, 1929, Vol. 124, pages 1037–1040.
Proper annealing is as important as proper chemical analysis in producing steel which will give lowest electrical losses. Silicon steels are most commonly used for magnetic purposes. Magnetic steel is annealed either before or after punching. Temperature must be uniform. Silicon steels are annealed at 725° C. and after 2 hours cooled slowly —150–200° C. Before the installation of electric furnaces, magnetic steels were annealed in oil-fired furnaces. Furnaces now used are the elevator type electric furnaces. They are filled with non-oxidizing gas, which not only prevents oxidation but reduces oxides which are present in the furnace. Contains illustrations showing construction of the furnace. Sums up advantages of electric furnace annealing. VSP(10b)

(c) Case Hardening & Nitrogen Hardening

World's Largest Nitriding Furnace. *Iron Age*, Oct. 24, 1929, Vol. 124, pages 1102–1103.
Describes world's largest nitriding furnace constructed by the Central Alloy Steel Corporation. It is a 580-kw. double-end car-type furnace used in hardening steel with ammonia gas. The furnace is 26 ft. long between doors, with an effective length of 24 ft. It is 5 ft. 9 in. wide and has a loading clearance of 4 ft. 8½ in. Nitriding box is 22 ft. long, 34 in. wide and 30 in. high. The nitriding temperature is 975° F. Work is kept in furnace 50–90 hrs. Largest charge to be nitrided so far is 2 tons. Products 11 ft. 6 in. can be nitrided. VSP(10c)

Comparative Researches of Heat-Treatment of Case-Hardened Steels. Helmut Lüpfert. *Foundry Trade Journal*, Vol. 42, page 13.
Abstract translation of article in Stahl und Eisen. Gives results of researches to determine the effect of the various methods of treatment on different kinds of case-hardened steels, and particularly the dependence of grain size on the heating temperature, the duration of heating and rate of cooling. See *Metals & Alloys*, May 1930, page 525. VSP(10c)

Present Status of Nitrided Steels. Henry A. DeFries. *Iron Age*, Sept. 26, 1929, Vol. 124, pages 841, 874.
From an address before the New York chapter of the American Society for Steel Treating, Sept. 19. Five different grades of chromium-molybdenum-aluminum steels, ranging in carbon from 0.12–0.55% are produced by Krupp in Germany. In America grades of 15% maximum, 0.20–0.30% and 0.30–0.40% of carbon are used. Other ingredients are: S, P, Si and Mn. These steels are made by the basic process. Low carbon nitralloys in annealed condition have a Brinell hardness of only 150–160. A preliminary quenching and drawing raises the hardness from 190–220 Brinell. The new method of hardening does not cause warping. In nitriding eutectic transformation point occurs at 1200° F. which causes lamination in the nitrided case. Usual working temperature is from 950–1100° F. The applications of nitriding alloys in Europe are more various than in America. VSP(10c)

JOINING OF METALS & ALLOYS (11)

(a) Brazing

Brazing and Welding. *Iron & Coal Trades Review*, Oct. 4, 1929, Vol. 119, page 515.
Translated abstract from Metallbörse. High chromium content often causes difficulty in soldering. Gives composition of alloys which are most suitable for soldering. Some alloys are liable to chemical attack at the joint. A mixture of borax and boracic acid makes a suitable flux. RHP(11a)

(c) Welding & Cutting

Another Oxy-Acetylene Welded River Crossing. W. I. Gaston. *American Welding Society Journal*, April 1930, Vol. 9, pages 52–60.
Illustrated description of 8″ high pressure gas line. HWG(11c)

The Economics and Advantages of Pipe Welding with Stock Fittings. W. P. Curley. *American Welding Society Journal*, April 1930, Vol. 9, pages 42–51.
Fittings for welding, to take the place of other types of elbows are made by forcing seamless tubing over a horn shaped mandrel at a forging temperature. This can be cut to give any angle desired. The fittings are made in the various alloys obtainable as seamless tubing. HWG(11c)

Strength Investigations on Welded Beam Connections. C. H. Jennings & A. A. Jakkula. *American Welding Society Journal*, April 1930, Vol. 9, pages 22–41.
Account of tests and discussion of engineering theory of various methods of welding beams to columns. Some of the results were checked by photo-elastic experiments on models. HWG(11c)

The All-Welded Barge, "Steelweld." E. H. Eweritz. *American Welding Society Journal*, April 1930, Vol. 9, pages 18–21.
Brief description. HWG(11c)

Copper and High Copper Alloy Welding. I. T. Hook. *The Metal Industry*, London, Nov. 29, 1929, Vol. 35, pages 520–521.
See *Metals & Alloys*, April 1930, Vol. 1, page 475. (11c)

Building Up Broken Gear Teeth. C. J. Drolz. *Machinery*, April 1930, Vol. 36, page 626.
Describes a bronze welding process used in Australia. RHP(11c)

The Influence of the Electric Arc Welding Process on the Design of Machinery. J. F. Lincoln. *Machinery*, April 1930, Vol. 36, pages 585–588.
Discusses several ways in which electric arc welding may be used. RHP(11c)

Repairing a Large Cylinder by Arc Welding. *Machinery*, Mar. 1930, Vol. 36, page 536.
Two 60-inch cracks in the cylinder wall of a vertical blowing machine were welded and returned to service in 325 hours. A new cylinder would have taken nine months' time and would have cost $12,000. The repair was less than 7% of this cost. Describes the methods used in the repair work. RHP(11c)

The Use of Electric Spot Welding. A. M. Searles. *Machinery*, Mar. 1930, Vol. 36, page 531.
This is a type of resistance welding which may best be done with the aid of mechanical and electrical equipment designed to perform the 5 following operations: 1. Apply pressure for holding the pieces of metal together. 2. Apply current to heat metals to fusion point. 3. Disconnect current just before the metals are completely melted. 4. Apply pressure to unite the metals in fusion. 5. Release the pressure to permit removal of the work. A good, modern welding machine will complete such an operation in a fraction of a second. RHP(11c)

Development and Application of Hard-Facing. Miles C. Smith. *Machinery*, Nov. 1929, Vol. 36, pages 219–222.
Description of a new process for applying a surface of hard alloy to a metal by fusion welding. RHP(11c)

The Applications of Both Welding and Riveting. *Iron Trade Review*, Jan. 2, 1930, Vol. 86, pages 26–27, 121.
Review of recent progress as seen by a number of authorities. MS(11c)

Economical Air Transmission. *Oxy-Acetylene Tips*, Vol. 8, pages 220–221.
One of the most important uses for the oxy-acetylene process in the sheet metal field is the fabrication of welded sheet metal piping for the transmission of air. An oxy-acetylene weld made with the proper welding rod will outlast the sheet metal and there are no seams to act as starting points for corrosion. Such welding facilitates the fabrication of offsets to avoid obstructions. MLM(11c)

Testing Steel Sheet for Weldability. De Witt Endicott. *American Welding Society Journal*, April 1930, Vol. 9, pages 16–17.
Melt the sheet part way through, moving the burner tip in a straight line, then hold the tip still until a hole is burned through. The tip should be one size smaller than is to be used on the sheet, the flame adjusted to neutral, and held 1/8″ from the sheet. The smoothness of the melted line and of the hole, and the freedom from oxide deposits are taken as criteria of the suitability of the sheet for welding. Poor welding quality is laid to the presence of non-metallic inclusions. HWG(11c)

Panel Heating, An Application of Welding. R. A. Wolff. *American Welding Society Journal*, April 1930, Vol. 9, pages 12–16.
Discussion of welding of hot water coils used in special heating system in the British Embassy. HWG(11c)

Atomic Hydrogen. Its Application to Welding of Metals. (L'hydrogen atomique. Application a la soudure des metaux.) Jean Brillie & Ernest Morlet. *Revue de Metallurgie*, Jan. 1930, Vol. 27, pages 19–36.
Includes a bibliography. A study of variables entering atomic hydrogen welding. Influence of electrodes and different gases on the stability of the arc. The action of different gases on W electrodes. Possibility of replacing H with different gases like C_2H_5OH vapors and ammonia was studied but with negative results. Consumption of electrodes and the influence of their composition on the qualities of the weld was well investigated. JDG(11c)

Synchronous Converters Now Arc-Welded. R. H. NEWTON & R. S. MARTHENS. *Electric Journal*, April 1930, Vol. 27, pages 195–199.
Seven figures illustrating applications of arc-welding to converter parts are shown and applications explained. WHB(11c)

Electric Welding of Heavy Materials. J. F. LINCOLN. *Iron & Steel Engineer*, March 1930, Vol. 7, pages 126–129.
A brief outline of applications of arc welding, with a discussion following. WHB(11c)

Arc Welded Buildings Permitted in 71 Towns. FRANK P. MCKIBBEN. *Electrical World*, Apr. 5, 1930, Vol. 95, pages 692–694; *Iron & Steel Engineer*, Mar. 1930, Vol. 7, page 151.
For welding buildings where 3/8" fillets are used, 175–200 amps. with an arc voltage of 18–20 gives satisfactory results for hand welding with 3/16" welding wire. The wire has practically the same chemical composition as structural steel with carbon of .0013–.0018%. WHB(11c)

WORKING OF METALS & ALLOYS (12)

Steel Making Practices Reviewed. *Iron Age*, Nov. 14, 1929, Vol. 124, pages 1307–1310; Nov. 21, 1929, pages 1382–1384; Dec. 5, 1929, pages 1528–1530.
Report of the Open-Hearth Committee of the American Institute of Mining & Metallurgical Engineers at Chicago, Nov. 5 and 6. Metal mixers were compared with Pugh mixer ladles. Pugh ladle gives less scrap loss and is cheaper than the installation of a mixer. Describes automatic tongs with auxiliary loops and extra bits for handling ingots and molds. Other equipment described—molds for large slab ingots and furnace controllers. Experiments on furnace using a combination of coke oven and blast furnace gas is inconclusive. Design of furnaces according to latest practice was found that local conditions in different plants require certain modifications of any general rule. Emphasizes the great need for fundamental research. Quality improvement in rimmed steel can be obtained by controlling evolution of gas in steel and its escape from ingot before solidifying. Low iron oxide in steel represents good quality. Pig iron should have silicon between 0.90 and 1.25%. New method for determining ratio of inclusions and method of calculations is described. The value of various deoxidizers is taken up. In conclusion the committee discussed the fundamental matters connected with the design of open-hearth furnaces with questions of quality control for steel. VSP(12)

(a) Melting & Refining

500 Kw.-Hr. per Ton for Steel Castings. DELTON T. WABY. *Electrical World*, Sept. 21, 1929, Vol. 94, page 574.
A Middle West foundry has melted 23,000 tons of steel in one furnace in three years with average consumption of 500 kw.-hr. per ton. The average charge was 5.8 tons, and the average time between heats, 10.2 minutes. The three years' record is tabulated. WHB(12a)

Electric Stereotype Pots Melt 1000 Pounds with 20 Kw.-Hr. J. L. FADEN. *Electrical World*, Jan. 11, 1930, Vol. 95, pages 113–114.
Data are presented for the operation of two 8-ton pots, each of 300-kw. capacity. The operating temperature is maintained at 650° F. by three circuits, thrown into circuit as required by automatic temperature control. Idle pots are kept at 650° F. by one circuit with the heaters in series connection. The average composition of stereotype metal is: tin, 5.6%, antimony, 14.1 and lead, 80.3%. Load curves of a newspaper plant on typical Sunday and Tuesday runs are shown. Energy consumption of 1000 pounds is 20.2 kw.-hrs. A 2½-ton pot of 20-kw. capacity is used for miscellaneous work, including the casting of flat plates. Electric heated scorchers, with 3-heat switches, are used for drying the mats. WHB(12a)

Steel Treaters Study Steel Melting. *Iron Age*, Sept. 26, 1929, Vol. 124, pages 827–829.
Being a review of the special session on steel metallurgy of the American Society for Steel Treating, Sept. 10. George A. Dorin read a paper on, "Slags Produced in Steel Making, Their Effects on the Product and on the Process Itself," in which he discussed the flaws and lack of uniformity in steel made by processes that attempt to finish and refine under slags carrying iron oxides. George Batty read a paper on, "Production of Electric Steel for Castings," in which the author said that methods applied in melting and finishing a heat of steel for castings must be considered of primary importance. Lawford H. Fry on the subject of locomotive forgings spoke of the various methods and precautions of correct methods from the melting to forging of the steel. The steel-making processes, and importance of ingot structure. H. P. Rassbach read a paper entitled, "Melting Practice for 3 Types of Electric Steel" in which the author stated that in plain carbon steels carbon content should be fairly close to desired carbon; in chrome-vanadium change should contain as much of desired alloys as are available from scrap on hand. Discusses melting practice and Logs of 3 types of heats. Each paper is discussed by various authorities. VSP(12a)

Electrical Iron and Steel Melting Performance. DELTON T. WABY. *Electrical World*, Dec. 7, 1929, Vol. 94, page 1131.
The table, from the Western Society of Engineers' Hunt Award paper for 1929, shows size of furnace, capacity, voltage, type of lining, hours per day, tons per month, number of charges, kw-hr. per ton and pounds of electrodes per ton of metal. WHB(12a)

Melting and Casting Magnesium. W. E. WARNER. *Metal Industry*, London, Aug. 30, 1929, Vol. 35, page 203.
Magnesium must be covered with a flux while molten on account of its oxidation and the ease with which it takes fire. A flux of 28% magnesium fluoride and 72% of magnesium chloride is used. Another flux is composed of 40 gms. calcium fluoride, 60 gms. sodium fluoride, 11.5 oz. potassium chloride and 2 lbs. anhydrous magnesium chloride. When melting the internal surface of crucible should be dressed internally with a wash of French chalk. To reduce oxidation attempts have been made to maintain CO_2 in crucible and mold. VSP(12a)

Future of Wrought Iron in the Agricultural Industry. JAMES ASTON. *American Metal Market*, Dec. 3, 1929, Vol. 36, pages 9 and 14; *Blast Furnace & Steel Plant*, Feb. 1930, Vol. 18, pages 291–293.
A new process of making wrought iron is outlined. The process conforms to puddling in all its essential steps, but they are separated and carried out in pieces of equipment best suited to the several phases. This permits control of operations, magnitude of production, uniformity of product and minimizing of labor to a degree not possible in puddling. Pig iron is melted continuously, the molten metal blown in side-blown Bessemer convertors and the disintegration and slag incorporation are carried out in a set of unlined stationary cups or thimbles, resting upon standards along the pouring platform. The cups are rectangular; one is supplied with 2½–3 ft. depth of slag of wrought iron characteristics, melted in an open-hearth furnace. Into this slag, one half of the ladle of blown metal is poured in a steady stream. Upon completion of the pour and quieting of the reactions, the cup is picked up by a crane and the large surplus of slag poured into an adjoining empty thimble. This second thimble now is the receiver for the second half of the blown metal. Make-up slag is brought from the melting furnace as needed, with a general requirement approximating lb. per gross ton of wrought iron produced. The decanted cup contains the solidified, spongy metal mass intermingled with liquid slag. This "ball" is transferred to a hydraulic press and, being at welding heat, is compacted to a solid, rectangular bloom which is immediately rolled to appropriate billet or bar sizes. A uniform product conforming in all particulars to the characteristics of quality wrought iron is the result. WHB(12a)

Electric Melting of Stereotype Plates Gains Headway. R. M. KEENEY. *Electrical World*, Apr. 5, 1930, Vol. 95, pages 707–708.
An abstract. The average analysis of stereotype metal of 5 newspaper plants was: tin, 5.6%, antimony, 14.1% and lead, 80.3%. Pouring temperature, depending upon thickness of plate and metal analysis is 550–775° F. The rapid growth of electric melting of stereotype metal is due to: (1) most gas-fired pots were non-insulated and without automatic control, which means that electric heat is cheaper than gas on a thermal basis; (2) electricity is often cheaper in newspaper plants where power presses and electrically-operated linotypes are in use; (3) improved working conditions; (4) lower maintenance cost of electric pots in comparison with gas; (5) cost of electrifying an insulated gas pot is little greater than the cost of insulating the gas pot and equipping it with automatic control. One paper with a daily circulation of 300,000 and using two 8-ton electric stereotype metal pots melts 1335 tons of metal per month with electrical consumption of 20 kw-hr. per 1000 lbs. of metal cast. WHB(12a)

(b) Casting & Solidification

Steel Billets Are Cast Centrifugally. J. D. KNOX. *Iron Trade Review*, Jan. 30, 1930, Vol. 86, pages 58–60.
Machine designed by Leon Cammen for Central Alloy Steel Corp. casts 8 bars 78 in. long, 18 in. wide and from ½ to 4 in. thick at one time. Unit includes a driving medium, pouring trough and a cylindrical mold partially fluted on the interior. In operation mold drum is revolved at about 275 r. p. m., about 3 min. being required to attain this speed. After completion of the pouring operation, the mold is kept spinning for about 1½ min. Machine makes soaking pits unnecessary, but a continuous furnace with a rack for storing the bars will be required for reheating steel before rolling. Total loss of metal, with the exception of trimming losses is not expected to exceed 3%. As there is no time lag in freezing between the shell and core of the billet, no segregation is encountered. MS(12b)

Casts Piston Rings Individually. EDWIN BREMER. *Foundry*, Jan. 15, 1930, Vol. 58, pages 64–68.
Cast-iron piston rings of small size are cast in pots while the large size are cast individually. Making rings individually is practical and has its advantages over piston pot method. Describes appliances and method employed by the Piston Ring Co., Muskegon, Mich. Metal for rings is melted in 3 cupolas. Metal charges of 800 lbs. are used with 130–150 lbs. coke splits between. The average analysis for rings under 5" diameter is: Si 2.85%, total carbon 3.50%, Mn 0.60–0.70%, S under 0.08% and P 0.50%. Rings 5" and over are made from iron containing 2.00% Si and 3.65% total carbon. The other elements are same as for smaller rings. The rings are produced by multiple molding. Gives detailed description of the method. VSP(12b)

Steel Ingots. W. H. HATFIELD. *Proceedings South Wales Institute of Engineers*, Feb. 11, 1930, Vol. 45, pages 523–562.
Hatfield discusses the formation of the aggregation of metallic crystals which constitute a steel ingot. The heterogeneity of the ingot is discussed. This is most noticeable for carbon, sulphur and phosphorus. Manganese, silicon, nickel, chromium and copper are more uniform in distribution. To decrease heterogeneity, Hatfield recommends (1) the steel should be "piping" steel, (2) the mold should produce an ingot with the biggest section at the top of the chill portion and should have an adequate refractory-lined feeder head, (3) the ingot should be cast with the steel at such a relatively low temperature that the temperature gradient in the liquid steel is never anything but a low value, (4) the size of nozzle should be suitable for the size of ingot and nature and temperature of the steel, (5) the steel should be effectively deoxidized before leaving the steel-making furnace and (6) the sulphur content should be at the lowest possible value, while phosphorus may advantageously be low. Contains discussion. See *Metals & Alloys*, June 1930, Vol. 1, page 568. AHE(12b)

The Centrifugal Casting of Iron Pipes. E. J. Fox. *Proceedings Staffordshire Iron & Steel Institute*, Session 1928–29. Vol. 44, pages 53–67.
Includes discussion. Describes process which originated in Brazil, taken up by small firm in Toronto and finally perfected by Stanton Ironworks Co., Ltd. Pipes of 12 feet length only are manufactured. Details of process are given. Pipe is formed in an accurately machined cylindrical steel mold, the dimensions of which coincide with outer dimensions of the finished pipe. Tilting ladle and cantilever trough supply molten metal to revolving mold. Only core used is that which is necessary to shape inside of socket. Rate of tilting ladle, the peripheral speed of the mold, and the traverse of the machine are all in a constant ratio for any size and thickness of pipe. After molten metal has been poured into mold it solidifies in a few seconds and when contraction has taken place the pipe is withdrawn. Due to rapid cooling of the pipe in the water-cooled mold, the outer skin of the pipe is slightly chilled requiring heat treatment to normalize this structure. Great care must be taken to insure perfect annealing which requires careful watching of temperatures at every point. Best results were obtained using casting temperature between 1220 and 1250° C. Care must be exercised in having correct metal composition. Gives tables showing results of mechanical tests on pipes as pipes and on the metal as produced by the centrifugal process. Tables also show results of similar tests on ordinary sand-cast pipes for comparison. Photomicrographs are given of spun iron and sand-cast iron. Includes photographs illustrating process. LFM(12b)

Some Factors in Solidification. S. W. SMITH. *Foundry Trade Journal*, Nov. 7, 1929, Vol. 41, pages 335–336, 340.
Address delivered to the London section of the Institute of Metals. Solidification of metals and alloys is essential in regard to their behavior in use. Necessity for disturbing molten metal by transfer from one receptacle to another is the cause of many troubles. Solidification of quiescent metals. Three stages in the operation of cupellation. As temperature falls several phenomena may be observed with solidification of molten metals. Factors in solidification process are: (1) oxidation of certain constituents, and how to remove; (2) degree of cohesion of metal in preserving its continuity; (3) rejection or retention of occluded gases; (4) surfusion; (5) volume change at solidification; (6) diminished cohesion; (7) forces of crystallization being restrained; (8) evidence of adhesion to the mold. VSP(12b)

(d) Forging

Drop Forgings and Machine Forgings. F. W. SPENCER. *Proceedings Staffordshire Iron & Steel Institute*, Session 1928–29, Vol. 44, pages 20–32.
Includes discussion. Deals with the various machines used for the production of forgings in steel and non-ferrous metals. Discusses the drop-hammer, dies and trimming tools, their methods of operation, hot-pressing machines and dies, methods of forging on upsetting machines and forging machine dies. In operation methods much attention must be given to see that the original fiber in the bar or billet is so directed in the preliminary working that the fiber in the finished forging will be in the best position to resist dynamic stresses when machines are placed in service. Describes friction screwpress and crankpress for the forging of brass. Temperature of 750° C. is required for brass while only 470° C. is needed for aluminum and other light alloys. Upsetting machine is especially useful for making automobile parts and is more economical than the drop forging hammer because waste is reduced to minimum. Upsetting machines are not used in England to any great extent. LFM (12d)

Book Reviews

Experimental Physical Chemistry. By FARRINGTON DANIELS, J. HOWARD MATHEWS & JOHN WARREN WILLIAMS. International Chemical Series. First Edition. McGraw-Hill Book Company, Inc., New York, 1929. Cloth, 5 1/2 × 8 inches, 475 pages, 132 figs. Price, $3.50.

The authors state that the purposes of this book are to illustrate the principles of physical chemistry, to train in careful experimentation, to develop familiarity with apparatus and to encourage ability in research. Even a brief examination will satisfy one that the purposes have been kept well in mind by the authors. The first part covering more than half of the book is devoted to 78 experiments which satisfactorily illustrate the principles of physical chemistry. In addition to the older and more classical experiments there are newer ones on such topics as partial molal properties of solutions, the activity function and the relationship between free energy and the equilibrium constant. Each experiment contains a brief development of the theory involved, apparatus required, procedure, calculations, mention of a few practical applications, some suggestions for further work and a number of references to journal articles, bulletins and other books. The second part adequately describes apparatus and technique both for the experiments in the first part and for certain kinds of more advanced work. The third part covers the remaining 30 pages and contains brief discussions of miscellaneous operations such as various calibrations, glass blowing and purification of materials. The book should make a host of friends among those engaged in research and technology as well as teachers and students of physical chemistry. The excellent lists of references scattered throughout the book will certainly be of great value for a more detailed study of apparatus and technique along any line of experimentation in which one is interested. There is practically nothing on high temperature technique which might serve as an introduction to physical chemistry of metallurgical processes; but such material hardly belongs in a book of this type and no claim for completeness is made by the authors. Of course, the fundamentals illustrated here can be applied to any system with proper ingenuity and development of experimental technique. The book is written clearly and concisely and has real merit for the purposes for which it is intended.—O. O. MILLER.

Le controle de la durete des metaux dans l'industrie. P. ROUDIE. Dunod, Paris, 1930. Paper, 6 1/2 × 10 inches, 114 pages, 6 figs. Price, 26 Fr.

One is seldom privileged to see a book in which a question of the greatest industrial importance has the light of creative criticism focused on it in a more graceful and thorough manner than in the present booklet.

It belongs to the type of work which does not introduce any radical changes in the conception of the subject, but presents already available data in the light of a thoroughly trained analytical mind so that its details, both welcome and negative, stand out sufficiently to attract attention, inevitably leading to further creative approach.

A clear understanding of a problem is the best approach to its solution. The presentation of the conception of hardness and of the methods for its determination can hardly be improved either in clearness or thoroughness. A brief picture of the chaos hiding under contemporary looseness of hardness definition and secondary phenomena entering into all known means for its determination is followed by an outline of six types of hardness generally accepted in the literature. Crisp reviews of testing methods, both obscure and well known, pass in a brief procession serving as an introduction to the scholarly discussion of the relation between elasticity and hardness, the twain not to be separated. On the foundation built in the preceding chapters the performance of scleroscope is critically examined on 35 pages explaining many peculiarities of the performance of this apparatus, apparently the most promising from the theoretical standpoint.

The author's knowledge of the subject is exhaustive ranging from highly theoretical studies of Weyl, Cauchy, Kelvin, etc., to thorough familiarity with industrial testing routine. The manner in which the small amount of mathematics present in this book is handled cannot be a better proof. M. Roudie is certain of his ground to the extent of permitting him to discard the annoying habit of many French writers of attaching themselves to the apron strings of some better known man via an introduction to their work.

In the preface the author mentioned that the volume under discussion is to be treated as a mere introduction to the forthcoming treatise on the subject. What it would be, one can only pleasantly speculate, because the reviewer cannot recollect a clearer, more comprehensive and better supported description and interpretation of hardness and of the phenomena accompanying the processes of its determination than is given in the mere introduction to it, the present little volume.—JOHN D. GAT.

Die Aluminum Industrie. By DR. RUDOLF DEBAR. Friedrich Vieweg & Sohn, Braunschweig, 1925. Paper, 338 pages, 61 plates, 5 3/4 × 9 inches. Price, 20 R. M.

Dr. Debar has condensed an enormous amount of information within the pages of a relatively small volume. The book tries to cover the entire German aluminum industry and is divided in the following sections:

1. The story of aluminum
2. The Hall-Heroult reduction process
3. Properties of aluminum
4. Alloys of aluminum
5. Application of aluminum and its alloys

The second section is very well treated from both a technical and practical standpoint. Debar does not neglect the economic phase and concludes this part by some interesting cost and profit figures. The discussion of the application of aluminum alloys is also very extensively treated for the space consumed. The volume is supplemented by tables of alloy compositions, physical properties and dimensions of alloy sheet, wire and channel shapes. There are a number of inaccuracies in nominal compositions of certain foreign and local alloys. A chronological list of the most prominent German patents is also given.

Debar has laboriously given minute descriptions of some of the important phases of a large industry. His lack of knowledge of foreign progress in some fields somewhat limits the range of consideration. The book leaves the impression of being tediously detailed for a short volume, yet not sufficiently exhaustive for a thorough description of the vast industry.—KENT R. VAN HORN.

Reviews of Manufacturers' Literature

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department*—EDITOR.

Sweetaloy Castings Chart.—Revised chart giving complete range of chrome-iron and chrome-nickel-iron alloys for corrosion and heat resistance with application data—covers line of alloy castings produced by Wm. J. Sweet Foundry Co., 8 Lister Avenue, Newark, N. J.

Pan Conveyors.—Four-page leaflet describing Amsco Manganese steel feeders and pan conveyors with illustrations, also capacity data. American Manganese Steel Co., Chicago Heights, Ill.

Ironton Fire Brick.—A four-page leaflet giving condensed but complete details of Ironton "extra service" fire-brick. The Ironton Fire Brick Company, Ironton, Ohio.

Durimet Fume Ducts.—Bulletin No. 501—a brief story about application and installation of Durimet Fume Ducts as made by the Duriron Company, Dayton, Ohio.

Oil Regulating Valves.—Data Sheet 701 gives condensed details of the Hauck Micro-Vernier Oil Regulating Valves. Illustrated. Hauck Manufacturing Company, 128 Tenth Street, Brooklyn, N. Y.

High-Speed Electric Furnace.—For heat-treating high-speed steel. A four-page leaflet describing outstanding features of the Model HB-2. American Electric Furnace Company, Boston, Massaschusetts.

Testing Machines.—Advance bulletin illustrating a few of the many Southwark-Emery testing machines. Southwark Foundry and Machine Co. 400 Washington Avenue, Philadelphia, Pa.

Grinders and Polishers.—Bulletin 20, sixteen pages, illustrates the many models and sizes, giving brief description and dimension data of the full line of electrical grinders and polishers manufactured by the Hammond Machinery Builders, Kalamazoo, Michigan.

Misco High Temperature Alloy.—A sixteen-page booklet illustrating manufacturing operations and some of the many casting possibilities of this high temperature alloy. The Michigan Steel Casting Company, Detroit, Michigan.

Serving Industry for Three Generations; Die Blocks; Forgings; Shear Knives; Electric Induction Steel.—A series of five bulletins describing Heppenstall equipment, alloys and service. Heppenstall Company, Pittsburgh, Pa.

Instructions for Installation and Care of Brown Electric Flow Meters.—Forty-page booklet 214 giving detailed instructions with illustrations. The Brown Instrument Company, Wayne Avenue, Philadelphia, Pa.

Industrial Control Catalog GEA-606B.—Complete with illustrations and descriptions of various industrial control items manufactured by the General Electric Company, Schenectady, N. Y.

Tantalum Enters the Industrial Field.—A technical booklet giving full details as to properties and characteristics of Tantalum. J. Bishop & Company Platinum Works, Malvern, Pa.

The Marine Uses of Nickel Alloys.—May 1930 issue of the Nickel Bulletin. The Mond Nickel Company Limited, Imperial Chemical House, Millbank, London, S. W. 1.

Tungsten, Molybdenum and Special Alloys.—Handbook giving history, properties and uses of these alloys in wire filament and other forms. Callite Products Company, 534—39th Street, Union City, N. J.

The Hyro Automatic Industrial Furnace.—Briefly described with illustrations in an eight-page folder entitled, "A Revolutionary Advance in Pot Furnaces" for case hardening by cyanide and other salts, heat treating, etc. Hyro Manufacturing Co., Inc., 200 Varick Street, New York.

Five Point Pipe.—A recently issued 40-page catalog giving the characteristics, manufacture and adaptability of genuine puddled Wrought Iron Pipe, showing illustrations of many interesting operations using this pipe. Reading Iron Company, Reading, Pa.

Corrosion Resistant Alloys in General Fabrication.—Analysis and physical properties of several types of chromium-iron and nickel-chromium-iron alloys and their applications. 24 pages. Downington Iron Works, Downington, Pa.

Arc Welding Sets.—Leaflet describes Flex-Arc Welding Sets. A new and outstanding feature of these gas engine-driven welders is the "Flexactor," a reactance which produces a steady, uniform and flexible arc at all currents. This Flexactor assures ease of striking and maintaining the arc at all current values, eliminates surges and smoothes out current variations. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Electric Furnace Gray Iron.—Four-page folder reprints a paper by G. L. Simpson read at the recent meeting of the New England Foundrymen's Association. Pittsburgh Electric Furnace Corporation, Pittsburgh, Pa.

Hydrogen-Ion Measurements.—Note Book 3, 1930, "Notes on Hydrogen Ion Measurements" is not a catalog nor any other type of direct advertisement. The notebook furnishes information that will be helpful to the large and rapidly increasing number of individuals interested in measuring the acidity and alkalinity of water solutions by electrical methods. The major portion of the text is devoted to a description of apparatus employed for measuring hydrogen-ion concentration. 48 pages. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

Spectrum Analysis.—Booklet, 24 pages. Bulletin No. 2 covers the quantitative analysis of metals and contains a bibliography of recent papers on spectrum analysis. An 8-page bulletin entitled "Steeloscopes" describes the Hilger spectroscopes for the rapid estimation of nickel, chromium, tungsten, copper, cobalt, etc., in steel. Adam Hilger, Ltd., 24 Rochester Place, London, N. W. 1, England.

Furnaces.—Leaflet Form SC 24 discusses the application of a roller hearth annealing furnace to the burning off and annealing operations of sheet metal stampings. The Surface Combustion Co., 2375 Dorr Street, Toledo, Ohio.

Nickel Cast Iron.—Small size 36-page booklet entitled "Notes on Uses of Nickel Cast Iron." Much of the information contained in this literature has already appeared in various trade journals but has been compiled so as to make it available for ready reference. International Nickel Company, 67 Wall Street, New York, N. Y.

Steel Castings.—A leaflet entitled "Green Lights of Safety" illustrates the application of steel castings to rail transportation. Lebanon Steel Foundry, Lebanon, Pa.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.

If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have the reference in METALS & ALLOYS. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department, METALS & ALLOYS, *419 Fourth Avenue, New York.*

United States Patents

Subject of Invention, Patentee, Patent No., and Filing Date

Tip for gas-burning apparatus. A. J. Fausek and I. F. Fausek. No. 1,762,-166. July 28, 1924.

Centrifugal casting machine. J. B. Ladd, assignor to United States Cast Iron Pipe & Foundry Co. No. 1,762,177. Jan. 19, 1928.

Electric furnace. H. W. Strong, assignor to The Strong, Carlisle and Hammond Co. No. 1,762,201. Apr. 6, 1928.

Cutting and welding apparatus. M. P. De Motte and R. C. Pierce, assignors to The Linde Air Products Co. No. 1,762,260. Nov. 4, 1921.

Device for selective handling of metal bars or billets. E. H. Fors, assignor to Morgan Construction Co. No. 1,762,291. Sept. 27, 1928.

Mold for metallic castings. A. L. Boegehold, assignor to General Motors Research Corp. No. 1,759,831. Aug. 1, 1927.

Pickling compound. P. J. Cole and C. Banta, assignors to the Barrett Co. No. 1,759,840. Oct. 21, 1928.

Casting mold for alumino-thermic welding. H. Schultz. No. 1,760,010. Feb. 18, 1926; in Germany Apr. 6, 1927.

Process of producing metal sheets by electrodeposition. H. M. Williams and R. G. Suman, assignors to General Motors Research Corp. No. 1,760,-028. Dec. 1, 1924.

Finned tube. H. W. Bundy, assignor by mesne assignments to Bundy Tubing Co. No. 1,760,038. July 14, 1927. No. 1,761,981. July 5, 1927.

Method of forming finned tubing into shapes. H. W. Bundy, assignor by mesne assignments to Bundy Tubing Co. No. 1,760,039. Feb. 6, 1928.

Ingot stripper. E. J. George, assingor of one-half to C. T. Howland. No. 1,760,054. July 19, 1928.

Process for the low-temperature reduction of iron ores. E. D. Newkirk and A. J. Briggs. No. 1,760,078. Oct. 3, 1927.

Electric heating apparatus. A. S. MacDonald, C. C. Waite, E. M. Huggins, assignors to Snead & Co. No. 1,760,155. May 16, 1923.

Process of treating malleabilized cast iron. C. F. Lauenstein and N. M. Waterbury, assignors to Link-Belt Co. No. 1,760,239. Dec. 29, 1926.

Heat treating of metals. C. F. Lauenstein, assignor to Link-Belt Co. No. 1,760,240. Nov. 7, 1927.

Metal. C. F. Lauenstein, assignor to Link-Belt Co. No. 1,760,241. Oct. 15, 1928.

Die-casting machine. M. Stern, assignor to A. C. Spark Plug Co. No. 1,760,258. July 16, 1928; No. 1,760,610. June 4, 1926.

Method and apparatus for rolling tubular articles. H. S. Newlin and W. E. Date; said Newlin assignor to the M. W. Kellogg Co. No. 1,760,278. Oct. 8, 1927.

Iron-nickel alloy. F. Stäblein, assignor to Fried. Krupp Akt.-Ges. No. 1,760,326. Oct. 31, 1928; in Germany Dec. 24, 1927.

Ductile chromium and method of producing the same. J. W. Marden and M. N. Rich, assignors to Westinghouse Lamp Co. No. 1,760,367. Apr. 27, 1926.

Zirconium and preparation thereof. W. P. Kiernan, assignor to Westinghouse Lamp Co. No. 1,760,413. Sept. 16, 1926.

Electron-emission material. H. E. Rentschler, J. W. Marden and C. T. Ulrey, assignors to Westinghouse Lamp Co. No. 1,760,440. (Original application filed June 25, 1921.) Dec. 23, 1922.

Manufacture of electron-emitting devices and the like. C. T. Ulrey, assignor to Westinghouse Lamp Co. No. 1,760,454. July 24, 1922.

Apparatus for removing cores from castings. A. Hansen. No. 1,760,495. Oct. 30, 1928.

Aluminum alloy. T. S. Fuller and D. Basch, assignors to General Electric Co. No. 1,760,549. Dec. 13, 1923.

Press-casting machine. C. J. Hult. No. 1,760,555. Apr. 23, 1928; in Sweden Mar. 29, 1926.

Method of making cylindrical articles from flat blanks. W. H. Klocke, assignor to the Cleveland Graphite Company. No. 1,760,558. Dec. 2, 1926.

Bearing and method of making same. W. H. Klocke, assignor to Cleveland Graphite Bronze Company. No. 1,760,559. Nov. 5, 1928.

Method of coating metals. E. R. Millring, assignor to American Machine and Foundry Co. No. 1,760,603. July 21, 1923.

Metal foil. W. J. Hawkins, assignor to American Machine and Foundry Co. No. 1,760,645. May 16, 1928.

Molder's flask. W. A. Moore and K. L. Moore. No. 1,760,711. Feb. 27, 1929.

Magnetic-core induction furnace. P. E. Bunet, assignor to Société Aciéreis de Gennevilliers. No. 1,760,741. May 25, 1928; in France June 2, 1927.

Pilger rolling mill. H. Idel, assignor to Demag Akt.-Ges. No. 1,760,757. June 16, 1927.

Heating furnace. A. R. McArthur and H. G. McIlvried, assignors to American Sheet and Tin Plate Co. No. 1,760,762. Jan. 24, 1928.

Composition of matter (Titanium nitride). W. H. Test. No. 1,760,922. Apr. 5, 1927.

Drying metal powders. R. P. Koehring and C. R. Short, assignors to the Moraine Products Co. No. 1,671,016. Nov. 7, 1927.

Heating furnace. H. M. Williams, assignor to General Motors Research Corp. No. 1,761,028. Nov. 21, 1927. (Original application filed Mar. 30, 1926.)

Composition for soldering metals. K. Geisel, assignor by mesne assignments, to Aluminum Solder Corp. of America, No. 1,761,116. May 28, 1928; in Germany Feb. 20, 1928.

Apparatus for bundling scrap stock. N. S. Guiden, assignor to J. H. Sessions and Son. No. 1,761,124. Feb. 21, 1927.

Process of manganese-compound recovery. N. A. Laury, assignor to J. V. Wiarda & Co. No. 1,761,133. July 22, 1925.

Method of welding. J. L. Anderson, assignor to Air Reduction Co., Inc. No. 1,761,167. Jan. 13, 1928.

Rolling-mill housing and bearing construction. J. R. George, assignor to Morgan Construction Co. No. 1,762,292. May 6, 1925.

Rolling mill. J. R. George and J. W. Sheperdson, assignors to Morgan Construction Co. No. 1,762,293. July 9, 1928.

Control and reversal of regenerative furnaces. G. H. Isley, assignor to Morgan Construction Co. No. 1,762,299. Nov. 19, 1926.

Reversing and controlling apparatus for regenerative heating furnaces. G. H. Isley, assignor to Morgan Construction Co. No. 1,762,300. Aug. 1, 1928.

Conveying mechanism. E. J. Quinn, assignor to Morgan Construction Co. No. 1,762,307. Apr. 9, 1927.

Optical pyrometer. A. Bestelmeyer, assignor to Hartmann & Braun, A. G. No. 1,762,380. July 16, 1926.

Toggle drawing press. W. Klocke, assignor to E. W. Bliss Co. No. 1,762,-398. June 14, 1928.

Welding device. W. F. Mecum. No. 1,762,402. Mar. 27, 1929.

Welding rod. W. B. Miller, assignor to Electro Metallurgical Co. No. 1,762,482. May 3, 1927.

Welding rod. S. M. Norwood, assignor to Electro Metallurgical Co. No. 1,762,483. Oct. 24, 1925.

Automatic hardness tester. C. H. Wilson, assignor to Wilson-Maeulen Co., Inc. No. 1,762,497. Aug. 12, 1926.

Hardness-testing method and apparatus. C. H. Wilson, assignor to Wilson-Maeulen Co., Inc. No. 1,762,498. Jan. 14, 1927.

Art of and mold for casting piston rings. M. O. Teetor, assignor to The Perfect Circle Co. No. 1,762,598. Aug. 12, 1927.

Process of preparing zinc dust and apparatus therefor. H. A. Grine, assignor to The Grasselli Chemical Co. No. 1,762,716. Nov. 29, 1927.

Heat treatment of magnetic materials. L. W. McKeehan, assignor to Bell Telephone Laboratories, Inc. No. 1,762,730. Oct. 30, 1926.

Tuyère. A. H. Fosdick, assignor to Bethelehem Steel Co. No. 1,762,814. May 21, 1928.

Means for forming metal tubes. F. H. Poeppelmeier, assignor to The Typographic Machines Co. No. 1,762,835. May 13, 1927.

Method of producing mercury. W. Glaeser, assignor to Glaeser Research Corp. No. 1,762,861. Nov. 14, 1924.

Process for working up complex ores and metallurgical products. F. Johannsen, assignor the the Firm Fried. Krupp Grusonwerk A.G. No. 1,762,-867. Jan. 21, 1927; in Germany Jan. 26, 1926.

Welding alloy. A. R. Lytle, assignor to Union Carbide & Carbon Research Laboratories, Inc. No. 1,762,871. Dec. 20, 1929.

Mold for head cores. W. D. Moore, *et al.*, assignors to Sand Spun Patents Corp. No. 1,762,876. Mar. 6, 1928.

Electric furnace method. W. E. Moore, assignor to Pittsburgh Research Corp. No. 1,763,248. Apr. 12, 1929. (Original filed June 19, 1928.)

Core gate for bath-tub molds and the like. C. J. Steele. No. 1,762,841. Apr. 5, 1928.

Metal rolling. J. B. Tytus, assignor to The American Rolling Mill Co. No. 1,763,279. June 20, 1925.

Noncorrodible reënforced pipe. O. V. Kean. No. 1,763,360. Jan. 22, 1927.

Furnace conveyer. G. F. Beach, assignor to Ryan, Scully & Co. No. 1,-763,386. May 31, 1927. (Original filed Apr. 8, 1926.)

Testing machine. R. B. Lewis, assignor to Tinius Olsen Testing Machine Co. No. 1,763,400. Oct. 8, 1924.

Means for and method of balancing. J. Lundgren, assignor to Tinius Olsen Testing Machine Co. No. 1,763,402. May 8, 1924.

Balancing device. J. Lundgren, assignor to Tinius Olsen Testing Machine Co. No. 1,763,403. Nov. 6, 1924.

Electrode for electric welding or soldering. E. J. Clarke, assignor to Alloy Welding Processes, Ltd. No. 1,763,417. Feb. 15, 1928; in Great Britain, Mar. 29, 1927.

Stable-surface alloy steel. R. P. De Vries. No. 1,763,421. Jan. 20, 1926.

Method of treating arsenious ore. A. R. Lindblad. No. 1,763,435. Dec. 1, 1927; in Sweden June 10, 1927.

Reverberatory furnace. F. F. Lines. No. 1,763,471. July 11, 1921.

Method for the manufacture of metal tubes. E. J. Gulick, assignor to C. G. Conn, Ltd. No. 1,763,582. June 29, 1928.

Method of manufacturing hollow drill steel. O. A. E. Gumaelius, assignor to Fagersta Bruks A.B. No. 1,763,651. Dec. 24, 1926; in Sweden Oct. 9, 1926.

Pneumatic jar-ramming molding machine. W. Lewis. No. 1,763,662. June 15, 1927.

Method of heat treating bits. F. J. Hinderliter. No. 1,763,704. Mar. 21, 1929. (Original filed Feb. 23, 1927.)

Metal-casting apparatus. A. Kadow, assignor to The Vacuum Casting Co. No. 1,763,710. June 2, 1928.

Molding machine. G. E. Pickup, assignor to The Wehrle Co. No. 1,763,-862. Sept. 24, 1926.

Welding machine. C. L. Rowland, assignor to American Welding Co. No. 1,763,867. Jan. 27, 1926.

Heat treatment of loaded conductors. G. W. Elmen, assignor to Western Electric Co. No. 1,763,884. May 29, 1926.

Method and mold for casting hollow metal articles. A. Law. No. 1,763,895. Feb. 27, 1929.

Soldering iron. N. Norris. No. 1,763,900. June 16, 1927.

Apparatus for moving ingots or masses in furnaces. H. Bangert and M. Peters, assignors to Ofenbau-Ges. m. b. H. No. 1,763,918. Mar. 23, 1926; in Germany May 23, 1925.

Furnace structure. J. F. Booraem and E. J. Hatton. No. 1,763,919. May 6, 1927; No. 1,763,920. May 12, 1927.

Alloy (Cu-Al-Zn-Fe). J. V. O. Palm, assignor to The Cleveland Graphite Bronze Co. No. 1,764,034. Oct. 1, 1926.

Terminal (For resistor furnace). J. Kelleher, assignor to Harper Electric Furnace Corp. No. 1,764,045. Feb. 29, 1928.

Steel sucker rod and the like and its production (Method of heat treating). W. J. Crook, assignor to Emsco Derrick & Equipment Co. No. 1,764,-068. Jan. 8, 1927.

Composition for oilless bearing and process for producing same. J. O. Carrey, assignor to Carrey-Morse Engineering Co. No. 1,764,094. Oct. 26, 1925.

Heat-resistant metal sheet (Sheet iron coated with Zn-Al alloy). E. R. Wehr and C. C. Mahlie, assignors to The American Rolling Mill Co. No. 1,764,132. Sept. 13, 1926.

Method of producing a composite metal. F. C. Leonard, assignor to Leonard-Rooke Co. No. 1,764,271. Dec. 8, 1925.

Control system for rolling mills. H. C. Jenks, assignor to Westinghouse Electric & Manufacturing Co. No. 1,764,312. Dec. 13, 1927.

Ore furnace. C. T. Knight. No. 1,764,313. Oct. 29, 1928.

Tunnel kiln. P. A. Meehan, assignor to American Dressler Tunnel Kilns, Inc. No. 1,764,460. Apr. 3, 1928.

Process for producing metals and alloys. T. R. Haglund. No. 1,764,511. Jan. 28, 1928; in Sweden Feb. 1, 1927.

Coating for surfacing permanent molds. H. L. Baumgardner. No. 1,764,544. Jan. 11, 1926.

Brazing rod (Cu-Zn-P). A. R. Lytle, assignor to U. C. & C. Research Labs., Inc. No. 1,764,571. Sept. 7, 1928.

Coating for welding rods. W. A. Wissler, assignor to Haynes Stellite Co. No. 1,764,589. Nov. 22, 1927.

Rolling mill. G. Asbeck, No. 1,764,598. July 21, 1926; in Germany June 3, 1926.

Art of soldering. G. Brunhübner, assignor to E. G. Bek. No. 1,764,604. Dec. 24, 1926; in Germany Oct. 12, 1925.

Oxidation inhibitor. R. S. Dean, assignor to Western Electric Co., Inc. No. 1,764,609. May 12, 1924.

Thoriated tungsten filament. J. H. Ramage, assignor to Westinghouse Lamp Co. No. 1,764,644. July 27, 1926.

Electrolytic system. J. W. Scott, assignor to Western Electric Co., Inc. No. 1,764,650. Dec. 23, 1926.

Composite casting. J. E. Hoy, assignor to The Dow Chemical Co. No. 1,764,725. Mar. 29, 1924.

Mandrel moving and cooling apparatus. L. Löwy, assignor to Schloemann Akt.-Ges. No. 1,764,736. Mar. 12, 1928; in Germany Mar. 21, 1927.

Annealing box. H. Williams and J. W. McHugh, assignors to Pittsburgh Steel Foundry Corp. No. 1,764,768. Feb. 10, 1928.

Process for improving the heads of railway rails. J. Lukasczyk. No. 1,764,-844. Aug. 25, 1927; in Germany Oct. 21, 1926.

Mold. H. A. Redmond, assignor to Harry J. Hater. No. 1,764,889. June 7, 1929.

Disk-rolling process. G. M. Evans, assignor to Budd Wheel Co. No. 1,764,943. Jan. 22, 1927.

Apparatus for removing cores from cast-iron pipes and the like. J. R. McWane, assignor to McWane Cast Iron Pipe Co. No. 1,765,022. July 2, 1928.

Core guide. J. R. McWane, assignor to McWane Cast Iron Pipe Co. No. 1,765,024. Mar. 2, 1929. (Original filed Mar. 19, 1928.)

Drawing machine. A. C. Belles, assignor to Union Drawn Steel Co. No. 1,765,047. Sept. 8, 1926.

Sprue-forming device. M. Stabile. No. 1,765,109. July 17, 1929.

Method and apparatus for forming molds. B. Bart, assignor to Bart Reflector Co., Inc. No. 1,765,320. Oct. 28, 1926.

Preparing metal for painting. J. H. Gravell, assignor to American Chemical Paint Co. No. 1,765,331. May 23, 1929.

Surface protection for magnesium alloys. R. E. Lowe, assignor to Doherty Research Co. No. 1,765,341. Mar. 14, 1927.

Alkaline oxidant and aluminum metal. A. Pietzsch and G. Adolph, assignors to Buffalo Electro-Chemical Co., Inc. No. 1,765,344. June 16, 1927; in Germany Sept. 3, 1926.

Roller-hearth furnace. F. T. Cope, assignor to The Electric Furnace Co. No. 1,764,007. Oct. 11, 1928.

Sintering machine. E. W. Shallock, assignor to American Ore Reclamation Co. No. 1,764,695. Oct. 12, 1928; No. 1,764,696. Mar. 25, 1929.

Apparatus for manufacturing bimetallic billets. H. E. McCrery and A. E. Jesser, assignors to Copperweld Steel Co. Reissue No. 17,717. (Original No. 1,747,784, filed June 23, 1926.) Apr. 16, 1930.

Method of welding. C. A. Frahm and E. W. Riemenschneider, assignors to The Union Metal Manufacturing Co. No. 1,765,368. Feb. 13, 1928.

Arc-welding system. A. K. Harford, assignor to New Metal Products Co. No. 1,765,373. Aug. 5, 1925.

Cap for hot tops. E. L. Messler and J. M. Guthrie. No. 1,765,382. May 9, 1929.

Furnace. J. Kubik. No. 1,765,430. Dec. 13, 1927.

Method of producing magnetic materials. P. S. McCann, assignor to Western Electric Co., Inc. No. 1,765,436. Nov. 6, 1924.

Wire-drawing apparatus. S. McMullan and A. E. Schulz, assignors to Western Electric Co., Inc. No. 1,765,437. Mar. 26, 1926.

Apparatus for discharging cores from castings and for cleaning castings. J. T. Stoney. No. 1,765,462. Feb. 21, 1927.

Continuous-pickling process. H. M. Naugle and A. J. Townsend, assignors to The American Rolling Mill Co. No. 1,765,498. Nov. 12, 1926.

Process for producing electrical resistance elements and the like. F. Eichenberger, assignor to Globar Corp. No. 1,765,572. May 5, 1923; in Switzerland May 11, 1922.

Automatic die-casting machine. E. Carlson, assignor to Stewart Die Casting Corp. No. 1,765,653. June 28, 1928.

Apparatus for coating metallic articles. W. H. Sommer. No. 1,765,743. June 26, 1928. (Division of original filed Nov. 7, 1927).

Method of making cast-metal wheels. F. W. Burger, assignor to Clark Equipment Co. No. 1,765,754. Aug. 10, 1925; renewed Nov. 27, 1929.

Appratus for making cast-metal wheels. F. W. Burger, assignor to Clark Equipment Co. No. 1,765,755. Aug. 10, 1925.

Metal-coated paper article and method of making same. A. L. Clapp. No. 1,765,862. July 16, 1926; renewed Mar. 18, 1930.

Rolling-mill housing. F. C. Czemba and H. W. Wilson. No. 1,765,907. May 11, 1927.

Process of soldering ornamental and other chains and chain mail of wire of solid cross-section. A. Maylein. No. 1,765,932. Sept. 27, 1926; in Germany Sept. 27, 1925.

Rotary furnace. M. Sklovsky, assignor to Deere & Co. No. 1,765,949. Nov. 10, 1927.

Apparatus for annealing rolled-metal products. E. von Maltitz and F. Willie, assignors to H. A. Brassert & Co. No. 1,765,955. Jan. 5, 1927.

Mold. A. T. Bateman and A. Irvine, assignors to Bohn Aluminum & Brass Corp. No. 1,766,093. July 30, 1928.

Apparatus for forming cup-shaped members. W. N. Booth, assignor to Kelsey-Hayes Wheel Corp. No. 1,766,098. May 2, 1927.

Metallurgical furnace. (Cupola.) D. Cushing. No. 1,766,110. (Division of No. 1,703,337 filed July 19, 1926; in Great Britain Sept. 26, 1927), Dec. 12, 1928.

Apparatus for welding hollow metallic articles. H. P. Sailor. No. 1,766,229. July 6, 1926.

Checkerwork. G. L. Danforth, Jr., and A. E. Peterson, assignors to Open Hearth Combustion Co. No. 1,766,283. July 31, 1928.

Pack opener. A. R. McArthur, assignor to American Sheet & Tin Plate Co. No. 1,766,299. Oct. 19, 1928.

Heat treatment of steel. W. B. Sullivan, assignor to Chrobaltic Tool Co. No. 1,766,314. June 2, 1926.

Production of metal films. W. E. Watkins, assignor to Copper Plate Sheet & Tube Co. No. 1,766,417. Jan. 6, 1927.

Metallurgy of tin. (Electrolytic reduction of cassiterite.) W. O. Snelling. No. 1,766,463. Mar. 5, 1928.

Apparatus for heat-treating metal articles. T. R. Heywood, Jr. No. 1,766,-633. July 19, 1929.

Method and material for preventing the tarnishing of silverware. G. Jones, assignor to Pacific Mills. No. 1,766,646. July 11, 1929.

Regulation of furnace electrodes. G. Keller, assignor to A. G. Brown, Boveri & Cie. No. 1,766,648. Sept. 30, 1926; in Germany Oct. 16, 1925.

Stereotype-plate-casting machine. C. A. Rupp, assignor to Commercial Iron Works of Los Angeles. No. 1,766,692. Aug. 21, 1928.

Machine for shaping hollow metal blanks. C. G. Anderson, assignor to S. H. Reynold Sons Co. No. 1,766,700. Dec. 2, 1926.

Machine for corrugating sheet metal. J. R. Freeze, assignor to The American Rolling Mill Co. No. 1,766,743. Mar. 28, 1928.

Alloy structure. (Laminated hollow cylinder.) H. M. Williams and A. L. Boegehold, assignor to General Motors Research Corp. No. 1,766,865. Apr. 6, 1923.

Lead alloy. S. Beckinsale and H. Waterhouse. No. 1,766,871. Apr. 11, 1927; in Great Britain Apr. 16, 1926.

Corrosion prevention of iron and steel. M. M. Harrison. No. 1,766,902. July 14, 1928.

Bending machine. C. H. Strupe. No. 1,766,963. July 13, 1928.

Alloy. (Zn-Al-Cu-Ni-Li.) C. Pack and J. C. Fox, assignors to Doehler Die-Casting Co. No. 1,767,011. Aug. 8, 1927.

Centrifugal casting machine. G. B. Thomas and H. A. Coons, assignors to M. F. Harrison Dental Supply Co. No. 1,767,023. Oct. 3, 1928.

Centrifugal pipe-mold structure. J. H. Uhrig, assignors to United States Cast Iron Pipe & Foundry Co. No. 1,767,024. June 29, 1928.

Centrifugal casting machine. L. B. Andresen, assignor to M. F. Patterson Dental Supply Co. No. 1,767,035. May 28, 1928.

Centrifugal casting machine. L. B. Andresen and C. W. Paulson, assignors to M. F. Patterson Dental Supply Co. No. 1,767,036. Dec. 8, 1928.

Method of and apparatus for casting metal ingots. H. A. Deuel. No. 1,767,-055. Mar. 3, 1928.

Ingot mold and ingot. E. Gathmann. No. 1,767,174. Aug. 12, 1929.

Method of electric (resistance) welding. R. D. Malm. No. 1,767,220. Dec. 17, 1928.

Continuous automatic cleaning and plating machine. C. G. Miller and C. F. Cleveland, assignors to The Meaker Co. No. 1,767,253. July 3, 1926.

Eccentric rolls for rolling mills and the like. A. E. Pinches, assignor of one-half to The Tinsley Rolling Mills Co., Ltd. No. 1,767,392. Jan. 26, 1928; in Great Britain Jan. 26, 1927.

Apparatus for the manufacture of hollow bodies. (By centrifugal casting.) A. Portevin, assignor to Soc. d'Expansion Technique. No. 1,767,394. Nov. 7, 1927; in France Nov. 10, 1926.

Welding machine. J. J. Paugh, assignor to Edward G. Budd Manufacturing Co. No. 1,767,473. Mar. 3, 1928.

Automatic spot-welding machine. C. L. Eksergian, assignor to Edward G. Budd Manufacturing Co. No. 1,767,521. Apr. 4, 1928.

Apparatus for molding castings. S. B. Stine. No. 1,767,563. May 31, 1929.

Hot mill catcher. D. Buccione, assignor to American Sheet & Tin Plate Co. No. 1,767,574. July 19, 1928.

Method of and apparatus for separating metal sheets. P. E. Hunter and L. E. Endsley. No. 1,767,587. June 17, 1929.

Electric soldering device. L. H. Moulthrop. No. 1,767,607. Sept. 17, 1927.

Mold wash. (For molds for casting Ni or Ni alloys.) A. E. Kayes and F. Moehling, assignors to The International Nickel Co. No. 1,767,764. Apr. 18, 1929.

Apparatus for producing metals from their oxide ores. W. E. Trent, assignor to The Trent Process Corp. No. 1,767,779. May 11, 1928.

Method of rolling disks. J. W. Hughes, assignor to Budd Wheel Co. No. 1,767,796. Oct. 5, 1927.

Furnace. (Open-hearth.) A. W. Smith and R. B. Jones. No. 1,767,817. Aug. 12, 1921.

Apparatus for drawing hollow blanks. H. Heetkamp, assignor to Demag A.G. No. 1,767,845. May 25, 1928; in Germany May 31, 1927.

Method of and apparatus for rolling tubes from a hollow block. M. Roeckner, assignor to Vereinigte Stahlwerek A.G. No. 1,767,896. Feb. 6, 1928; in Germany Feb. 25, 1927.

Ladle for low-melting materials. I. Gonyk. No. 1,767,975. Aug. 23, 1928; in Germany Aug. 26, 1927.

Treating manganese ores. (Silico-thermic reduction.) J. H. Brennan, assignor to Electro Metallurgical Co. No. 1,768,112. June 28, 1928.

Soldering iron. F. R. Raymond, No. 1,768,147. Oct. 3, 1928.

Apparatus for hardening metal surfaces. A. E Shorter and C. L. Boucher, assignors to The Patent Gear Hardening Co., Ltd. No. 1,768,159. Dec. 21, 1927; in Great Britain Sept. 29, 1927.

Machine for hardening irregular surfaces. A. E. Shorter and C. L. Boucher, assignors to The Patent Gear Hardening Co., Ltd. No. 1,768,160. Dec. 21, 1927; in Great Britain Sept. 29, 1927.

Mechanism for shaking out molds. E. S. Carman, assignor to The Osborn Manufacturing Co. No. 1,768,233. Jan. 14, 1927.

Magnetic material. G. W. Elmen, assignor to Western Electric Co., Inc. No. 1,768,237. Aug. 5, 1925; No. 1,768,238. Jan. 12, 1927.

Casting mechanism. J. E. Hoy, assignor to The Dow Chemical Co. No. 1,768,254. Nov. 12, 1926.

Process of carburizing iron or steel. R. G. Guthrie and O. J. Wozasek, assignor to People Gas By-Products Corp. No. 1,768,317. Mar. 30, 1929.

Electrolytic process and apparatus. H. C. Harrison. No. 1,768,358. May 21, 1925.

Means for making molds. J. W. Hazell. No. 1,768,359. Dec. 31, 1926.

Apparatus for cleaning castings. J. T. Stoney. No. 1,768,428. June 28, 1924.

Method for forming sand molds. J. T. Stoney. No. 1,768,429. Aug. 16, 1924.

Magnetic material and appliance. (Fe-Ni-Mo.) G. W. Elmen, assignor to Western Electric Co., Inc. No. 1,768,443. July 12, 1926.

Continuous-car-tunnel furnace and method of operating the same. D. P. Ogden. No. 1,768,486. Nov. 12, 1924.

Drawing press. A. A. Byerlein, assignor to General Machinery Corp. No. 1,768,503. Dec. 21, 1927; No. 1,768,504. Nov. 8, 1928.

Hardness-measuring means. A. L. De Leeuw. No. 1,768,512. Oct. 19, 1925.

Bearing. (Porous sheet metal.) C. R. Short, assignor to The Moraine Products Corp. No. 1,768,528. May 5, 1927.

Method of making bearings. C. R. Short, assignor to The Moraine Products Corp. No. 1,768,529. May 5, 1927.

Casting-cleaning apparatus. W. T. Clark, assignor to Whiting Corp. No. 1,768,570. July 12, 1927.

Stable-surface alloy steel. (Fe-Al-Cr-Cu-C). R. P. De Vries. No. 1,768,-578. Jan. 20, 1926.

Furnace. F. J. Droege. No. 1,768,583. Oct. 31, 1928.

Process for the direct reduction of iron from its ores. S. L. Madorsky, assignor to Gathmys Research Corp. No. 1,768,622. Nov. 25, 1925.

Method of and converter for bessemerizing. E. I. Williams. No. 1,768,649. Apr. 22, 1929.

Babbitted shim and method of making the same. J. C. Yordon, assignor to Laminated Shim Co., Inc. No. 1,768,653. Aug. 27, 1925.

Utilization of converter slags for the manufacture of alloy steel. P. G. Paris, assignor to Bethlehem Steel Co. No. 1,768,710. Mar. 11, 1927.

Annealing pot. R. S. Stewart, assignor to The American Brake Shoe & Foundry Co. No. 1,768,719. Oct. 12, 1927.

Rotary heat-treatment furnace and lining for same. E. H. Mix, assignor to The Bourne-Fuller Co. No. 1,768,776. Feb. 8, 1929.

Method and apparatus for forming greensand cores. J. T. Stoney. No. 1,768,802. Aug. 12, 1926.

Ingot mold. H. M. Fletcher. No. 1,768,835. Apr. 20, 1927; renewed Sept. 23, 1929.

Template-holding stand for use with cutting torches. P. Orzel. No. 1,768,857. Feb. 10, 1926.

Heating-element-mounting construction. E. L. Smalley, assignor to Hevi Duty Electric Co. No. 1,768,865. May 22, 1928.

Metal-extruding apparatus. D. L. Summey. No. 1,768,866. Feb. 20, 1928.

Induction furnace. P. H. Brace, assignor to Westinghouse Electric & Manufacturing Co. No. 1,768,881. Aug. 14, 1929.

Annealing pot. R. B. Pogue, assignor to The American Brake Shoe & Foundry Co. No. 1,768,929. Feb. 25, 1929.

Molding machine. C. G. Keller. No. 1,768,960. Apr. 16, 1929.

Spot-welding machine. W. F. Koelpin, assignor to International Harvester Co. No. 1,768,987. Nov. 5, 1928.

Dop-casting apparatus. E. Loesser and E. W. Loesser, assignors to New Diamond Tool Polishing Co. of America, Inc. No. 1,768,990. Apr. 23, 1929.

Flux-coated electrode. (For arc welding). A. M. Ross. No. 1,768,998. Apr. 12, 1927; refiled Apr. 29, 1930.

Furnace. T. W. Clark, assignor to The Strong Carlisle & Hammond Co. No. 1,769,053. July 16, 1926.

Molding flask. I. R. Smith, assignor to Sterling Wheel-Barrow Co. No. 1,769,078. Mar. 21, 1929.

Method of and apparatus for forming sectional cores. L. E. Keen, assignor to The Wanner Malleable Castings Co. No. 1,769,141. June 7, 1926.

Electric welding machine. E. Lunn, assignor to Pullman Car & Manufacturing Corp. No. 1,769,148. Mar. 1, 1929.

Automatic (chromium) plating machine. H. Rabezzana, assignor to A C Spark Plug Co. No. 1,769,188. Nov. 2, 1928.

Extrusion machine. W. R. Clark, assignor to Bridgeport Brass Co. No. 1,769,205. May 2, 1924.

Metallurgical furnace construction. G. L. Danforth, Jr., assignor to Open Hearth Combustion Co. No. 1,769,209. Dec. 27, 1921.

Furnace. Same patentee and assignee. No. 1,769,210. Jan. 28, 1922.

Metallurgical furnace and port construction. Same patentee and assignee. No. 1,769,211. Feb. 2, 1922.

Furnace and post construction. Same patentee and assignee. No. 1,769,212. Mar. 15, 1922.

Metallurgical furnace. Same patentee and assignee. No. 1,769,213. Apr. 6, 1922.

Furnace. (Open-hearth.) A. M. Gow. No. 1,769,220. June 17, 1921.

Electric furnace process and apparatus. A. Isliker, assignor to The Ajax Metal Co. No. 1,769,223. July 23, 1923; in Switzerland Aug. 23, 1922.

Bullet and the manufacture of same. E. J. Johnson. No. 1,769,263. Apr. 12, 1927; in Canada Mar. 25, 1927.

Furnace for the production of aluminum. E. R. Lauber. No. 1,769,298. June 28, 1926; in Germany July 30, 1925.

Cyanide pot. V. P. Rumely, assignor to Hudson Motor Car Co. No. 1,769,313. Dec. 4, 1928.

Method and apparatus for forming sheet-metal channels. L. S. Lamb, assignor to Hudson Motor Car Co. No. 1,769,349. Dec. 28, 1927.

Open-hearth furnace. B. P. Wheeler. No. 1,769,362. June 17, 1921.

Method and means for producing metallic coatings on articles such as type forms and the like. N. Arvidson. No. 1,769,363. Dec. 22, 1924.

Open-hearth port design. G. L. Danforth, Jr., assignor to Open Hearth Combustion Co. No. 1,769,366. Oct. 8, 1921.

Open-hearth-furnace construction. Same patentee and assignee. No. 1,769,-367. Nov. 28, 1921.

Furnace construction. Same patentee and assignee. No. 1,769,368. Apr. 6, 1922.

Babbitting machine. F. L. Saxton. No. 1,769,394. Apr. 20, 1928.

Roasting of ores and the like. F. L. Wilder *et al.*, assignors to Electro-Metallurgical Ore Reduction, Ltd. No. 1,769,405. Mar. 29, 1928; in Great Britain Apr. 6, 1927.

Electric heat-treating apparatus and process. G. B. Ames, assignor to L. H. Morin. No. 1,769,407. Nov. 8, 1927.

Furnace construction. E. J. McDonnell, assignor to Open Hearth Combustion Co. No. 1,769,446. May 16, 1921.

Open-hearth-furnace construction. Same patentee and assignee. No. 1,-769,447. May 16, 1921.

Core for undercut cup-shaped articles. T. Pickering, assignor to Doehler Die-Casting Co. No. 1,769,455. Aug. 28, 1929.

Method of casting cylinder heads. Same patentee and assignee. No. 1,-769,456. Aug. 28, 1929.

Open-hearth furnace. G. L. Danforth, Jr., assignor to Open Hearth Combustion Co. No. 1,769,492. Sept. 26, 1921; No. 1,769,494. Apr. 4, 1930. (Division of original filed Sept. 26, 1921.)

Open-hearth-furnace port. Same patentee and assignee. No. 1,769,493. Oct. 9, 1922; renewed Apr. 11, 1930; No. 1,769,678. July 10, 1922.

Furnace. Same patentee and assignee. No. 1,769,495. Apr. 4, 1930. (Division of original filed Sept. 26, 1921.)

Furnace construction. Same patentee and assignee. No. 1,769,496. Apr. 4, 1930. (Division of original filed Sept. 26, 1921.)

Method of protecting sheet metal. (With water-soluble soap compound.) R. Z. Hopkins, assignor to Hudson Motor Car Co. No. 1,769,577. Feb. 26, 1927.

Dental casting machine. J. A. Phillips, assignor to Burns Dental Casting Machine Co., Inc. No. 1,769,603. Feb. 16, 1929.

Metallurgical process. (Extraction of metals from ores containing copper and iron.) R. D. Pike. No. 1,769,604. Sept. 27, 1928.

Process for making electrolytic iron. R. D. Pike. No. 1,769,605. Mar. 13, 1926.

Thermostat. W. M. Chace (deceased), assignor to W. M. Chace Valve Co. No. 1,769,622. Jan. 27, 1928.

Thermostatic element. W. M. Chace (deceased), assignor to W. M. Chace Valve Co. No. 1,769,623. Aug. 16, 1928.

Open-hearth furnace. R. S. A. Dougherty, assignor to Open Hearth Combustion Co. No. 1,769,826. May 8, 1922.

Open-hearth furnace. A. T. Keller, assignor to Open Hearth Combustion Co. Nos. 1,769,842 and 1,769,843. Dec. 5, 1921.

Open-hearth furnace and method of heat generation. F. Orth, assignor to Open Hearth Combustion Co. No. 1,769,853. Feb. 7, 1921.

Open-hearth furnace and the like. Same patentee and assignee. No. 1,769,-854. Sept. 6, 1924. (Division of original filed Feb. 7, 1921.)

Furnace. H. E. Smythe, assignor to Open Hearth Combustion Co. No, 1,769,863. Jan. 9, 1922.

Furnace. R. H. Stevens, assignor to Open Hearth Combustion Co. No. 1,769,866. Sept. 22, 1921.

Austrian Patents

Subject of Invention, Patentee, Patent No. and Date of Beginning of term of Patent.

Highly heat resistant cast chrome-iron alloys. Meier & Weichelt. No. 118,022. Mar. 15, 1928.

Means for accelerating cooling in electric bright-annealing furnaces. A. G. Brown, Boveri & Cie. No. 117,833. Jan. 15, 1930.

Device for decreasing the effect of the pressure of the metal jet in die-casting molds. S. Junghans. No. 117,888. Jan. 15, 1930.

Tubular rotary furnace. L. Tocco and M. Landi. No. 117,828. Jan. 15, 1930.

Process for purifying metals, particularly light metals, such as magnesium, by filtering. British Maxium, Ltd. No. 117,847. Jan. 15, 1930.

Induction melting furnace. Allgemeine Elektrizitäts Gesellschaft, assignee of W. Höpp. No. 117,684. July 15, 1930.

Electrode for electric furnaces. B. Redlich. No. 117,825. Jan. 15, 1930.

Process and apparatus for the production of alkali metals and halogens by electrolysis of fused halogen compounds. Deutsche Gold- und Silber-Scheideanstalt, vorm. Roessler. No. 118,014. Sept. 15, 1928.

Method of and means for heating rolled material. B. Witting. No. 118,177. Feb. 15, 1930.

Process for rolling sheet and strip iron. Eisen und Stahlwerk Hoesch A.G. No. 118,418. Nov. 15, 1929.

Process for reducing ores, particularly iron ores. Nybrgs Gruf AB. No. 118,214. Feb. 15, 1930.

Recuperator lined with hollow refractory brick. K. Kniepert. No. 118,225. Feb. 15, 1930.

Means for operating electric annealing furnaces. A. G. Brown, Boveri & Cie. No. 118,215. Feb. 15, 1930.

Electric salt-bath crucible furnace. Siemens-Schuckertwerke A.G. No. 118,222. Feb. 15, 1930.

Device and method for determining the relative position of two objects, particularly the position of a core with respect to the ribs of a piston. Bohn Aluminum and Brass Corp. No. 118,266. Feb. 15, 1930.

Hard alloy. Deutsche Luxemburgische Bergwerks- und Hütten A.G. No. 118,061. Jan. 15, 1929.

Process for producing aluminum by fusion electrolysis. I. G. Farbenindustrie A.G. No. 118,219. Feb. 15, 1930.

Device for spraying a plurality of objects. Metallisator Berlin A.G. No. 118,443. Aug. 15, 1927.

Machine for pressing metal into tubular form. International Western Electric Co., Inc. No. 118,175. Feb. 15, 1930.

Welding burner for electric arc welding. "Elin" A.G. für elektrische Industrie. No. 118,181. Feb. 15, 1930.

Device for electric arc welding. Siemens-Schuckertwerke A.G., assignee of W. Raupach. No 118,221. Feb. 15, 1930.

Device for simultaneously hardening the heads of a plurality of railroad rails. Eisenwerk Ges. Maximilianhütte. No. 118,186. Feb. 15, 1930.

British Patents

Note: Names of communicators, if any, are given in parentheses after the name of the applicant. When the date applied for differs from the date on which the application was lodged at the British Patent Office, the former date is given, followed by *.

Subject of Invention, Patentee, Patent No. and Filing Date.

Reduction of tin and other metals from their salts and the purification of molten baths of metal salts. E. A. Ashcroft and F. E. Elmore. No. 329,159. Feb. 26, 1929.*

Process for increasing the elongation limit and tensile strength of low-carbon steels. Vereinigte Stahlwerke A.G. No. 300,553. Nov. 14, 1927.*

Oven for the reheating of iron flats or sections. S. A. D'Ougree Marihaye. No. 329,268. Oct. 25, 1928.*

Manufacture of hollow metal bodies. G. Turton, Platts & Co., Ltd., and A. P. Fitzjohn. No. 329,259. Dec. 17, 1928.

Non-corrodible metal. W. Haddon and J. Winfield. No. 329,361. Jan. 16, 1929.

Method of manufacturing the cylinder blocks of internal-combustion engines. J. H. Rackham and Sheepbridge Stokes Centrifugal Castings Co., Ltd. No. 329,271. Feb. 6, 1929.

Method and apparatus for annealing metal bands. Electric Furnace Co., Ltd. No. 305,951. Feb. 11, 1928.*

Production of cast iron containing little gas or oxides. C. Brackelsburg. No. 306,141. Feb. 16, 1928.*

Crucible furnaces for melting metals. H. Bailey. No. 329,365. Feb. 13, 1929.

Restoration of the inner walls of ingot molds. H. A. Waldrich Ges. No. 309,122. Apr. 5, 1928.*

Electrolytic deposition of heavy metals. M. Schlötter. No. 329,324. Nov. 9, 1928.*

Electrolytic processes and baths therefor. M. Schlötter. No. 329,308. Feb. 14, 1929.

Method of manufacturing aluminum wires or aluminum alloy wires. Vereinigte Aluminium-Werke A.G. No. 306,898. Feb. 27, 1928.*

Machine for bending and sawing metal goods. Darlington Rolling Mills Co., Ltd., *et al.* No. 329,344. Feb. 16, 1929.

Production of easily soldered metal coatings. M. Schlötter. No. 329,346. Feb. 16, 1929.

Method of and apparatus for heat-treating signalling-conductors. Electrical Research Products, Inc. No. 306,541. Feb. 24, 1928.*

Heat-treatment of loaded conductors. Electrical Research Products, Inc. No. 306,543. Feb. 24, 1928.*

Manufacture of molded or rolled articles. W. H. Boorne. No. 329,382. Feb. 19, 1929.

Process for producing shaped bodies having a predominating percentage of tungsten or molybdenum. F. Krupp A.G. No. 310,876. May 2, 1928.*

Apparatus for preparing molders' sand. G. F. Royer. No. 311,428. May 12, 1928.*

Method of manufacturing seamless forged receptacles for high pressure. F. Krupp A.G. No. 312,918. June 2, 1928.*

Packaging of tin plate. H. D. Scott. No. 314,378. June 26, 1928.*

Separation of iron from solutions containing cobalt and rich in iron, such as those obtained by lixiviating roasted pyrites. H. E. Potts. (Orkla Grube-AG.) No. 329,543. June 18, 1929.

Compression of molding masses for the production of casting molds and cores. M. Grindal. No. 329,553. Oct. 5, 1928.*

Forging machines. Schiess-Defries A.G. No. 316,098. July 21, 1928.*

Production of composite metals suitable for hot rolling by casting-on coatings of copper-zinc alloys. Metallgesellschaft A.G. *et al.* No. 329,572. July 30, 1929.

Presses for drawing sheet metal. C. J. Rhodes. No. 329,589. Aug. 29, 1929.

Process of casting light metals, more particularly magnesium and alloys thereof, in sand molds. I. G. Farbenindustrie A.G. No. 319,272. Sept. 19, 1928.*

Electric furnaces. R. Schmitz. No. 302,594. Dec. 16, 1927.*

Process of producing pure aluminum compounds suitable for the production of aluminum. W. Bachmann. No. 307,345. Mar. 5, 1928.*

Titanium steel and its production processes. W. Mathesius and H. Mathesius. No. 329,705. Feb. 25, 1929.

Rolling-mills. F. Kocks. No. 308,785. Mar. 31, 1928.*

Heat-treating furnaces. H. O. Breaker. No. 307,301. Mar. 3, 1928.*

Muffle furnaces. Gibbons Bros., Ltd., and T. E. Bridgford. No. 329,787. Apr. 19, 1929.

Chrome bath for producing especially white, soft and easily polished chromium deposits. No. 310,427. Apr. 25, 1928.*

Electric furnace. H. G. Campbell. No. 329,830. May 15, 1929.

Means for ladling metal. Ferric Engineering Co. No. 313,173. June 8, 1928.*

Alloys. Westinghouse Electric & Manufacturing Co. No. 317,785. Aug. 22, 1928.*

Articles of high resistance to wear, well polishable and neutral to chemical agents. Dr. F. Hauptmeyer. No. 329,953. Jan. 27, 1930.

Apparatus for heating billets and the like. H. A. Dreffein. No. 302,651. Dec. 19, 1927.*

Furnaces for heating articles. H. A. Dreffein. No. 302,652. Dec. 19, 1927.*

Alloy steels. Vereinigte Stahlwerke A.G. No. 307,492. Mar. 10, 1928.*

Method of and apparatus for annealing metal strips. Electric Furnace Co., Ltd. No. 312,988. June 4, 1928.*

Molds for the manufacture of castings from metals or alloys. J. Y. Johnson. (I. G. Farbenindustrie A.G.) No. 330,018. Mar. 11, 1929.

Production of firmly adhering electrolytic metal deposits upon articles plated in the molten bath. H. Stefke. No. 330,040. Mar. 26, 1929.

Automatic press-machines for producing electrodes for galvanic elements. W. Hasse. No. 330,082. Apr. 26, 1929.

Electric devices for heating a metal melt within the ladle. F. Krupp A.G. No. 312,063. May 18, 1928.*

Manufacture of alloys, particularly for the production of sheets, etc., permeable to cathode-, X-rays and the like. Rohm & Haas A.G. No. 313,527. June 12, 1928.*

Case-hardening furnace with charging device of worm type. H. Lindhorst. No. 330,188. Aug. 22, 1929.

Forging machines. Schiess-Defries A.G. No. 330,209. Oct. 29, 1928.*

Cadmium plating. C. H. Humphries. No. 330,289. Oct. 1, 1928.*

Rotary cooling-bed for use in rolling mills. Demag A.G. No. 316,285. July 27, 1928.*

Electromagnetically-controlled hydraulic governors for electric metallurgical furnaces. L. Tagliaferri. No. 330,337. Apr. 2, 1929.

Tube mills. Maschinenbau-Anstalt Humboldt. No. 310,342. Apr. 23, 1928.*

Mechanically-operated sheet-metal stamping-presses. Hooven Owens Rentschler Co. No. 312,640. May 29, 1928.*

Production of hollow castings. Gebr. Lungen Ges. No. 315,301. July 11, 1928.*

Alloys. A. C. Spark Plug Co. No. 330,401. Apr. 1, 1929.*

Method of soldering. S. G. S. Dicker. (N. V. Philips' Gloeilampenfabrieken.) No. 330,403. June 10, 1929.

Process of hardening copper. N. O. Hedman *et al.* No. 330,408. June 17, 1929.

Electric furnace. C. E. Cornelius. No. 303,798. Jan. 9, 1928.*

Electric furnaces. L. D. J. Tisseyre. No. 305,631. Feb. 8, 1928.*

Muffle furnaces or the like. E. A. Hailwood. No. 330,512. Mar. 4, 1929.

Electric welding. Electrical Research Products, Inc. No. 307,923. Mar. 16, 1928.*

Insulated cooling systems for electrodes. F. S. Smith. No. 330,622. Mar. 11, 1929.

Anti-friction metals and bearings thereof. F. L. Ball *et al.* No. 330,577. Mar. 11, 1929.

Electrolytic deposition of metal on metal tubes. J. Stone & Co.,, Ltd., *et al.* No. 330,639. Mar. 15, 1929.

Flux-coated electrodes for electric welding. J. Mehl. No. 310,341. Apr. 23, 1928.*

Machines for drawing metal. H. Renold, Ltd., and A. Renshaw. No. 330,704. Apr. 26, 1929.

Manufacture of metal pipes or like castings. E. Moussiaux. No. 330,764. June 7, 1929.

Rolling metal tubes. Mannesmannröhren-Werke. No. 314,387. June 26, 1928.*

Electric welding machines. F. P. McBerty. No. 330,828. Aug. 15, 1929.

Foundry sand-mixer. J. F. Turner. No. 330,834. Sept. 7, 1929.

Furnaces particularly adapted for heat-treatment of railway tires and similar articles. J. Baker & Co. (Rotherham) 1920, Ltd., and S. E. Baker. No. 330,844. Sept. 27, 1929.

Forming of sheet metal. A. E. White. (E. G. Budd Manufacturing Co No. 330,582. (Divided on No. 302,723). Dec. 10, 1928.*

Canadian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Metallurgical furnace. D. Cushing. No. 300,281. Dec. 12, 1928.

Flux for welding magnesium alloys. I. G. Farbenindustrie A.G., assignee of E. de Ridder and W. Neuhaus. Nos. 300,288 and 300,289. June 12, 1929.

Process of casting light metals in sand molds. I. G. Farbenindustrie A. G., assignee of E. Player. No. 300,390. Sept. 19, 1929.

Method of making cast iron of high tensile strength. The International Nickel Co., Inc., assignee of F. B. Coyle. No. 300,398. Feb. 24, 1928.

Method of making anodes. The International Nickel Co., Inc., assignee of W. J. Harshaw *et al.* No. 300,399. June 5, 1928.

Process of extracting nickel and cobalt. The International Nickel Co., assignee of A. B. Bogsar. No. 300,400. Apr. 16, 1929.

Method of casting and treating articles. The Ohio Brass Co., assignee of A. O. Austin. No. 300,412. Oct. 31, 1929.

Apparatus for heating billets. H. A. Dreffein. No. 300,476. Nov. 5, 1928.

Compounds for casting metals. B. F. Wallace. No. 300,519. May 28, 1929.

Pot. The Flannery Bolt Co., assignee of F. K. Landgraf and E. S. Fitzsimmons. No. 300,578. May 22, 1928.

Electrodeposition of metals. The Imperial Chemical Industries, Ltd., assignee of J. Hollins and D. Jepson. No. 300,952. Jan. 11, 1929.

Process of welding nickel and its alloys. L'Air Liquide, S. A. pour l'Etude des Procédés Georges Claude, assignee of M. Michaud. No. 300,599. July 3, 1929.

Process for separating cobalt and iron from solutions. Orkla-Grube A. B., assignee of N. E. Lenander. No. 300,607. July 4, 1929.

Vanadium alloy. The Vanadium Corp. of America, assignee of B. D. Saklatwalla. No. 300,623. Jan. 11, 1929.

Conveying element for heat treating furnaces. F. A. Fahrenwald. No. 300,639. July 27, 1928.

Furnace conveyor disk. F. A. Fahrenwald. No. 300,640. Jan. 21, 1929.

Extraction of tin from ores containing tin. E. A. Ashcroft. No. 300,654. June 22, 1928.

Apparatus for treating metal sheets. The Copperized Steel, Ltd., assignee of E. R. Knapp. No. 300,785. Aug. 24, 1927.

Process of treating sheet metal. The Copperized Steel, Ltd., assignee of W. E. Watkins. No. 300,787. Aug. 26, 1927.

Method of controlling the sag of sheet metal strips in furnaces. The Copperized Steel Ltd., assignee of A. F. Clarke. No. 300,788. Aug. 29, 1927.

Process of treating ores and metallurgical products. F. Krupp-Grusonwerk A.G., assignee of F. Johannsen. No. 300,828. Nov. 24, 1928.

Decomposition process for the recovery of zinc. H. H. Mayer and R. G. La Motte. No. 300,879. Oct. 1, 1929.

Machine for casting hollow articles. Messrs. Boggild & Jacobsen. No. 300,942. Oct. 25, 1929.

Hot blast stove. H. A. Brassert & Co., assignee of H. A. Brassert and F. W Barrett. No. 300,943. Oct 29, 1928.

Tungsten-tantalum alloy. The Canadian Westinghouse Co., Ltd., assignee of J. H. Ramage. No. 300,951. Sept. 29, 1927.

Production of tantalum by electrolysis of fused compounds. The Canadian Westinghouse Co., Ltd., assignee of F. H. Driggs. No. 300,953. Dec. 31, 1928.

Manufacture of electrolytic zinc. I. G. Farbenindustrie A.G., assignee of K. Teufel and F. Stietzel. No. 300,970. Feb. 25, 1928.

Blast furnace apparatus. J. C. Hopkins *et al.* No. 301,054. June 19, 1929.

Flask. J. F. Hines. No. 301,106. May 28, 1925.

Method of producing metal blocks. (By centrifugal casting.) A. Keup. No. 301,116. Apr. 2, 1929.

Electric resistance element for electric furnaces. H. J. McCauley. No. 301,126. Aug. 16, 1929.

Apparatus for manufacturing forged steel wheels. P. P. Salter. No. 301,136. Dec. 9, 1929.

Wire-drawing die. M. Simons. No. 301,142. Dec. 23, 1929.

Production of aluminum. Aluminum Industrie A.G., assignee of J. Weber and A. von Zeerleder. No. 301,159. June 2, 1927.

Metallic resistor for electric furnaces. The Electric Furnace Co., assignee of T. F. Baily. No. 301,186. Aug. 15, 1929.

Resistor grid. The Electric Furnace Co., assignee of F. T. Cope and A. H. Vaughan. No. 301,187. Aug. 15, 1929.

Electric furnace. The Electric Furnace Co., assignee of F. T. Cope and A. H. Vaughan. No. 301,188. Aug. 29, 1929.

Method of coating metals. The Parker Rust Proof Co., assignee of V. M. Darsey. No. 301,239. Aug 21, 1929.

Process of producing phosphate coatings on metals. The Parker Rust Proof Co., assignee of M. Green and V. M. Darsey. No. 301,240. Aug. 21, 1929.

Method of preparing iron articles for rust proofing. The Parker Rust Proof Co., assignee of E. M. Jones. No. 301,241. Sept. 3, 1929.

Oxide cathode manufacture. The Radio Corp. of America, assignee of J. Van Der Hoeven. No. 301,243. Apr. 5, 1927.

Checkerwork construction. The Shea-Whelpley Construction Co., assignee of E. G. Whelpley. No. 301,254. June 28, 1929.

Molding machine. The Tabor Manufacturing Co., assignee of W. Lewis. No. 301,261. May 10, 1929.

Alloyed iron and steel. (Alloyed with chromium.) T. R. Haglund. No. 301,352. Nov. 16, 1927.

Process of making iron and steel. S. Westberg. No. 301,388. Jan. 17, 1925.

Process of refining iron and steel. S. Westberg. No. 301,389. Jan. 17, 1925.

Method of forming pistons. (By forging.) The Champion Machine & Forging Co., assignee of L. W. Greve. No. 301,433. Aug. 12, 1929.

Danish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for the production of metallic protective layers on metals. American Machine & Foundry Co. No. 42,139. July 6, 1928.

Process for the production of thick insulating coatings on aluminum and aluminum alloys. E. W. Küttner. Nos. 42,152 and 42,153. May 18, 1929.

Process for welding and heating metals and alloys. I. G. Farbenindustrie A.G. No. 42,202. Feb. 8, 1929.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Machine for rolling twist drill blanks. Rohde & Dorrenberg. No. 687,288. Dec. 27, 1929.

Process for purifying magnesium and its alloys. I. G. Farbenindustrie A.G., Frankfurt a.M., Germany. No. 687,274. Dec. 26, 1929.

Process and apparatus for treating zinc. St. Joseph Lead Co. No. 687,350. Dec. 28, 1929.

Improvements to high-frequency induction furnaces for heat treating metals and refractory materials. C. Mohr. No. 687,529. Mar. 23, 1929.

Annealing muffle. Société Robert Zapp. No. 687,670. Jan. 4, 1930.

Improvements to high-strength gray cast iron and to processes for making the same. The International Nickel Co. No. 687,677. Jan. 4, 1930.

Mechanical roasting furnace. Erzrostung G.m.b.H. Addition No. 36,778. (First addition to No. 631,914 filed Mar. 31, 1927.) Feb. 20, 1928.

Process for soldering metallic cables. A. Labbé. No. 687,306. Dec. 27, 1929.

Process and apparatus for the continuous spraying of molten substances. Hirsch Kupfer und Messingwerke A.G. No. 687,354. Dec. 28, 1929.

Centrifugal machine for casting pipes and for similar applications. Centrifugal Pipe Corp. No. 687,416. Dec. 30, 1929.

Process and apparatus for casting metals and ceramic materials by centrifugal force. C. Fritzsche. No. 687,459. Dec. 31, 1929.

Improvements to wire-drawing dies. M. Simmons. No. 687,568. Dec. 31, 1929.

Drum furnace for melting metals. C. Brackelsberg. No. 687,643. Jan. 3, 1930.

Installation for annealing metal objects. S. A. Brown, Boveri & Cie. No. 687,720. Jan. 6, 1930.

Improvements to electric muffle furnaces. Société en nom collectif Deliot et Cheminat. No. 687,732. Dec. 27, 1929.

Refractory linings or crucibles for electric induction furnaces. Associated Electrical Industries, Ltd. No. 687,379. Dec. 28, 1929.

Alloy. H. Kanz. No. 687,778. Jan. 7, 1930.

Molds for casting metals or alloys. I. G. Farbenindustrie A.G. No. 687,960. Nov. 2, 1929.

Aluminum alloy for pistons. Karl Schmidt G.m.b.H. No. 688,076. Jan. 13, 1930.

Process for producing aluminum or aluminum salts. Colloid Chemische Forschungs A.G. No. 687,725. Jan. 6, 1930.

Process for making chill molds. P. Wette and H. Kloss. No. 688,082. Jan. 13, 1930.

Improvements to hot tops for ingot molds. W. M. Charman. No. 688,126. Dec. 30, 1929.

Rotary furnace for melting metals. Cie. du Chemin de Fer de Paris á Orleans and L. J. Audo. No. 688,146. Jan. 13, 1930.

Process for granulating liquid slag. Gelsenkirchener Bergwerks A.G., and E. Opderbeck. Addition No. 36,868. (First addition to No. 570,690 filed Sept. 10, 1923.) May 6, 1929.

Process for tinning or coating with other materials. G. Boutefeu. No. 687,730. Jan. 6, 1930.

Process and machine for making sand cores. F. H. Morehead. No. 687,751 Jan. 6, 1930.

Process and apparatus for making bearings by shaping strips of sheet metal The Cleveland Graphite Bronze Co. No. 687,783. Jan. 7, 1930.

Improvements in the joining of metal sheets used in the paper industry and similar industries. Cie. Generale d'Electricite. No. 688,120. Dec. 23, 1929.

Cutting and welding torch using liquid fuel. G. Lotzow, S. Weil and S. Bloch. Addition to No. 36,857. (First addition to No. 661,950 filed Oct. 10, 1928.) May 2, 1929.

Process for the electric welding of double-barreled firearms. R. Gilson. No. 688,004. Jan. 10, 1930.

Process and apparatus for the electrolytic production of magnesium. I. G. Farbenindustrie A.G. No. 687,744. Jan. 6, 1930.

Improvements in the cooling of induction furnaces. Soc. Générale d'Applications Electrothermiques. No. 687,924. Mar. 27, 1929.

Improvements to electroplating apparatus. Cie. Française pour l'Exploitations des Procédés Thomson-Houston. No. 688,070. Jan. 13, 1930.

Inoxidizable metal. W. Haddon and J. Winfield. No. 688,299. Jan. 15, 1930.

Improvements to alloys of iron, chromium and nickel. The International Nickel Co., Inc. Nos. 688,358 and 688,359. Jan. 16, 1930.

Improvements in the production of metals and alloys by reduction. W. B. Hamilton and T. A. Evans. No. 688,442. Jan. 18, 1930.

Process for separating cobalt and nickel. W. Savelsberg. No. 688,491. Jan. 20, 1930.

Improvements to nitriding boxes. Central Alloy Corp. No. 688,616. Jan. 21, 1930.

Process for remelting and refining zinciferous residues. R. Thomas and F Scheiber. No. 688,469. Jan. 22, 1930.

Process for making weldless tubing. P. Kiefer. No. 688,208. Jan. 14, 1930.

Improved draw bench. S. A. des Usines de Fabrication de Tubes et des Forges de Sosnowice. No. 688,277. Apr. 8, 1929.

Device for heating round bars before rolling. L. Gendarme. No. 688,326. Jan. 16, 1930.

Process for making silverplated metal objects, for example tableware. M. H. Wilkens & Söhne A.G. No. 688,332. Jan. 16, 1930.

Process and apparatus for expanding metal tubing. Mannesmannröhren-Werke. No. 688,338. Jan. 16, 1930.

Process and machine for continuous electric welding. The Randall Co. No. 688,347. Jan. 16, 1930.

Improvements to welding electrodes and to the process for making them. Fansteel Products Co., Inc. No. 688,357. Jan. 16, 1930.

Improvements to control devices of tube-drawing benches. L'Aluminium Français. No. 688,534. Apr. 10, 1929.

Improvements in the fabrication of aluminum or other light alloy pistons. S. A. des Ateliers Rémy. No. 688,619. Jan. 21, 1929.

Improvements to process for casting thin plates or panels of large surface area. R. De Fleury. Addition No. 36,898. (First addition to No. 640,893 filed Feb. 25, 1927.) Feb. 18, 1929.

Process and machine for the electric forging and blanking of iron and steel shapes. E. Giacchino. Addition No. 36,906. (Second addition to No. 644,554 filed Sept. 26, 1927.) Feb. 18, 1929.

Improvements to automatic precision drawing dies. Ateliers Bariquand et Marre. Addition No. 36,914. (First addition to No. 674,856 filed Sept. 25, 1928.) May 10, 1929.

Process for the production of aluminum by electrolysis. O. M. Henriques and T. A. Thomsen. No. 688,567. Jan. 20, 1930.

Process for separating aluminum and silicon from aluminum silicates for the purpose of manufacturing silicon-free aluminum compounds or metallic aluminum. O. M. Henriques and T. A. Thomsen. No. 688,563. Jan. 20, 1930.

Pistol for spraying a coating on to brittle objects such as sand molds. Electro Metallurgical Co. No. 688,839. Jan. 25, 1930.

Process for coarsening the grain of sulphide ores during desulphurization. The International Nickel Co., Inc. No. 688,967. Jan. 27, 1930.

Alloy. H. Kanz. No. 689,079. Jan. 29, 1930.

Rapid method for determining the rusting tendencies of ferrous alloys. Vereinigte Stahlwerke A.G. No. 689,093. Jan. 29, 1930.

Process for treating complex ores of vanadium. Société de Produits Chimiques des Terres Rares. Addition No. 36,972. (First addition to No. 669,-115, filed June 1, 1928) Mar. 13, 1929.

Process for creping aluminum foil. Aluminiumwerke A.G. No. 688,685, Jan. 22, 1930.

Improved device for cold-bending metal tubing. C. Mingori. No. 688,752. Jan. 23, 1930.

Apparatus for the heat treating and the continuous hardening of steel wire, with recuperation of heat. R. L. T. Giraudeau. No. 688,777. Jan. 23, 1930.

Improvements in the torch welding of easily oxidizable metals. La Soudure Autogène Française. No. 688,915. Apr. 17, 1929.

Brazing solder. Allgemeine Elektrizitäts Gesellschaft. No. 689,008. Jan. 28, 1930.

Process for making duplex castings, in which one metal forms a core and is enclosed by the other metal. M. Yasumoto. No. 689,045. Jan. 29, 1930.

Improvements in the rolling of wide-flange channel iron. W. Neuhaus. No. 689,058. Jan. 29, 1930.

Improvements to arc-welding electrodes. Imperial Chemical Industries, Ltd. No. 689,085. Jan. 29, 1930.

Improvements to wire-drawing machines. Morgan Construction Co. No. 689,113. Jan. 30, 1930.

Process for fabricating metal shapes. H. Seiferth. No. 689,116. Jan. 30, 1930.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for rolling twist drills. P. Hunger, Bez. No. 500,221. Dec. 5, 1926.

Process for briquetting iron ore concentrates by using comminuted iron for binder. P. Gredt. No. 500,412. Feb. 10, 1927.

Device for arc welding ribbed plates to iron sleepers. Siemens-Schuckertwerke A.G. No. 500,322. Aug. 16, 1927.

Process for producing castings in a pneumatic die casting machine. L. Frommer. No. 500,227. Nov. 15, 1925.

Detinning aluminum. Metallgesellschaft A.G. No. 500,188. Mar. 21, 1929.

Recovery of tin from stanniferous material. W. Witter, and Hüttenwerke Trotha A.G. No. 500,420. Jan. 13, 1926.

Production of potassium from potassium fluoride. I. G. Farbenindustrie A.G. No. 500,331. Aug. 6, 1927.

Flux for tin-lead-cadmium solder using in soldering sheet zinc and galvanized iron. F. E. Krauss. No. 500,287. Jan. 15, 1928.

Heating device, used particularly in rolling round rods and wire. L. Gendarme. No. 500,594. May 29, 1929; in Belgium Jan. 28, 1929.

Device for measuring the thickness of rolled material. E. Günther. No. 500,595. Jan. 19, 1928.

Process for producing butt-welded tubing from uncut, rolled strip iron. N. Hertlin. No. 500,809. Nov. 5, 1926.

Device for adjusting piston and mandrel of tubing extrusion presses. Hydraulik G.m.b.H. No. 500,810. Nov. 18, 1928.

Machine for deforming sheet metal. H. Junkers. No. 500,811. (Addition to No. 480,469.) Dec. 19, 1928.

Process for producing pure iron. I. G. Farbenindustrie A.G. No. 500,692. May 24, 1925.

Charging device for cupolas. H. Quartier. No. 500,821. Nov. 10, 1928.

Charging device, particularly for shaft furnaces. Süddeutsche Waggonfabrik G.m.b.H. & Co. Kom.-Ges. No. 500,822. Oct. 28, 1927.

Process for decomposing titanium ores by treatment with a reducing agent and chlorine. I. G. Farbenindustrie A.G. No. 500,584. Sept. 29, 1925.

Method of firing regenerative hearth furnaces with coal dust. Witkowitzer Bergbau- und Eisenhütten-Gewerkschaft and C. Salat. No. 500,792. Feb. 10, 1927.

Process for producing low-carbon iron or steel, alloyed with chromium or manganese. T. R. Haglund. No. 500,982. Oct. 27, 1927; in Sweden Feb. 9, 1927.

Furnace for continuously bright-annealing metallic objects in an air-free gaseous atmosphere. A. G. Brown, Boveri & Cie. No. 500,823. Dec. 28, 1926.

Furnace with annular hearth subdivided into chambers. I. Achelin and K. Hummel. No. 500,824. Dec. 28, 1927.

Process for making electric heating elements. Allgemeine Elektrizitäts Gesellschaft. No. 500,534. Apr. 9, 1927.

Device for operating electric annealing furnaces. A. G. Brown, Boveri & Cie. No. 500,930. June 24, 1926.

Process for welding laminar bodies. A. Ignatieff. No. 500,624. Oct. 21, 1926.

Arc welding apparatus using alternating current. S. A. des Ateliers de Sécheron. No. 500,840. Jan. 24, 1926.

Process for the production of composite ingots. Vereinigte Stahlwerke A.G. No. 500,630. Nov. 19, 1929.

Mechanical roasting furnace with rotating central element. Witkowitzer Bergbau- und Eisenhütten-Gewerkschaft and A. Andziol. No. 501,026. Nov. 5, 1927.

Purifying foundry metals. A. Kirchhof. No. 500,942. (Addition to Patent No. 432,304.) Dec. 6, 1928.

Recovery of tin from anode slimes and intermediate products of chemical and metallurgical processes. F. Michel. No. 500,644. Apr. 12, 1929.

Device for suspending wares in electroplating baths operating at high current density. R. Blasberg. No. 500,949. Aug. 10, 1928.

Process and apparatus for filtering electrolytic baths. Riedel & Co. No. 500,-950. Jan. 23, 1929.

Electrolytic process for coloring copper and copper alloys. H. Debach. No. 500,951. Aug. 27, 1927.

Sheet-straightening machine. Edward G. Budd Manufacturing Co. No. 501,195. July 31, 1925; in the United States May 29, 1925.

Hot-straightening machine for sheets. Gebr. Irle Machinenfabrik. No. 501,-076. Nov. 22, 1929.

Process for making a welded pipe connection. F. Heck. No. 501,377. May 28, 1926.

Decomposing chromium ores. I. G. Farbenindustrie A.G. No. 501,391. Aug. 25, 1925.

Induction furnace, particularly for melting metals having a low melting point. E. F. Russ. No. 501,183. Apr. 21, 1925.

Process for preventing undulations in thin-walled metal bodies. Württembergische Metallwarenfabrik. No. 501,239. June 16, 1929.

Production of rolled bars from aluminum scrap. K. Albrecht. No. 501,185. July 29, 1926.

Copper alloys containing silicon. Metallgesellschaft A.G. No. 501,413. Mar. 6, 1927.
Copper alloys. Metallgesellschaft A.G. No. 501,125. Apr. 18, 1925.
Process for coloring copper and copper alloys. H. Debach. No. 501,286. Aug. 27, 1927.
Welding burner compasses. Drägerwerk, Heinr. & Bernh. Dräger. No. 501,146. Feb. 5, 1929.
Means for preventing the wire cutting into the blocks of wire-drawing machines. Drahtindustrie Peter Darmstadt & Co. G.m.b.H. No. 501,711. Oct. 9, 1927.
Machine for pressing objects out of metal or similar materials. P. C. Christiansen. No. 501,712. Feb. 26, 1929; in Denmark Mar. 1, 1928.
Machine for distorting sheet metal. H. Junkers. No. 501,713. (Addition to No. 477,153.) June 28, 1925.
Process for drawing shells of pure zinc. W. Erfurth. No. 501,714. (Addition to No. 477,766.) Aug. 25, 1929.
Process for desulphurizing roasted pyrites. I. Cavalli. No. 501,613. Sept. 21, 1927; in Italy Oct. 7, 1926.
Process for briquetting manganese ore. P. Gredt *et al.* No. 501,585. Mar. 10, 1926.
Process for regenerating the electrical properties of strips, sheets, wires, etc., made of iron alloyed with silicon. O. H. Döhner. No. 501,586. Sept. 5, 1926.
Process for making high-strength structural iron members. Vereinigte Stahlwerke A.G. No. 501,477. (Addition to No. 374,429.) Jan. 1, 1929.
Aluminum-zinc alloy improved according to Patent 445,714. Th. Goldschmidt A.G. No. 501,513. (Addition to No. 445,714.) Dec. 10, 1926.
Process for making one-piece hollow molds for galvanoplastic purposes. Württembergische Metallwarenfabrik. No. 501,789. Jan. 1, 1928.
Soldering tungsten and molybdenum. N. V. Philips' Gloeilampenfabrieken. No. 501,792. Nov. 8, 1927; in the Netherlands Dec. 23, 1926.
Plug for aluminothermic crucibles. J. Sáček. No. 501,793. Jan. 20, 1929.

Norwegian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Structural steel. Vereinigte Stahlwerke A.G. No. 47,937. Feb. 28, 1929.
Air- and acid-tight sealed electric heating resistances. W. B. Smits. No. 47,939. Feb. 16, 1929.
Process for electroplating metals with chromium. R. Appel. No. 47,947. May 15, 1926.
Aluminum alloy. Deutsche Versuchsanstalt für Luftfahrt E. V. No. 47,948. Apr. 20, 1927.
Process for the continuous production of sponge metals. H. G. Flodin. No. 48,048. July 10, 1928.
Process for making duplex castings. Aluminium, Ltd. No. 48,058, Dec. 18, 1928.
Special furnace for the reduction of metallic oxides. W. H. Smith. No. 48,078. Oct. 6, 1926.
Process for making ore briquettes. E. A. A. Grönwall. No. 48,112. June 14, 1928.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Method of making forged axles by hammering or pressing. E. Kamp. No. 69,415. Dec. 29, 1928. Priority Date June 26, 1928.
Process for forming protective layers on carbon and graphite electrodes. Siemens-Plania A.G. für Kohlefabrikate. No. 69,437. Dec. 8, 1925. Priority Date Dec. 30, 1924.
Electric heating element and process for making it. K. Isserstedt. No. 69,438. Apr. 30, 1927.
Machine for joining sheet metal radiator sections. A. B. Platförädling. No. 69,439. (Addition to No. 67,365.) Aug. 27, 1927. Priority Date Oct. 18, 1926.
Process for treating liquors containing copper and zinc. Patent/A.B. Gröndal-Ramen. No. 69,444. Aug. 27, 1927.
Process for the reduction of ores. Nybergs Gruf A. B. No. 69,476. Dec. 23, 1927.
Process for the production of a rust-resistant alloy. W. B. Hamilton and T. A. Evans. No. 69,477. Jan. 24, 1923. Priority Date May 23, 1922.
Device for rabbling the charge in electric furnaces. Société Electrométallurgique de Montricher. No. 69,486. Priority Date Feb. 7, 1928
Process for making cast steel. Meboe, Ltd. No. 69,492. Mar. 18, 1927. Priority Date Mar. 19, 1926.
Corrosion-proof bronze alloy and process for making the same. J. Harden and H. Tillquist. No. 69,614 Mar. 5, 1927.
Process for smelting oolitic granules obtained from minette ore, and similar fine-grained ores. P Gredt. No. 69,708. Sept. 10, 1925. Priority Dates Sept. 16 and Nov. 10, 1924.
Process for treating nickel-iron alloys. N. V. Philips' Gloeilampenfabrieken. No. 69,709. June 11, 1928. Priority Date July 19, 1927.
Process for separating components from alloys. H. Harris. No. 69,719. July 2, 1925. Priority Date Dec. 11, 1924.
Process for producing a metallic coating on electrically non-conducting material. British Metallising Co. No. 69,724. Feb. 12, 1928.
Partition for the separation of electrolytic products in the fusion electrolysis of chlorides. I. G. Farbenindustrie A. G. No. 69,757. Nov. 24, 1928. Priority Date Dec. 23, 1927.
Method of welding sheet metal. J. Bargen. No. 69,807. May 10, 1927. Priority Dates May 20, June 8 and Oct. 1, 1926.
Process for the reduction of metals from their ores. E. A. A. Grönwall and H. J. H. Nathorst. No. 69,831. Sept. 13, 1928.
Process for treating metals. Pittsburgh Research Corp. No. 69,832. May 21, 1928.
Process for arc welding in a protective atmosphere. Allgemeine Elektrizitäts Gesellschaft. No. 69,851. Oct. 17, 1927. Priority Date Nov. 9, 1926.
Alloy steel. Glockenstahlwerke A. G. vorm. Rich. Lindenberg. No. 69,900. July 22, 1924.

Swiss Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for the electrolytic production of thick insulating layers on aluminum and its alloys. E. W. Küttner. No. 137,219. May 18, 1929; in Germany May 22, 1928.
Apparatus for cleaning metals, particularly machine parts. Hahn and Kolb. No. 137,220. Dec. 17, 1928; in Germany Jan. 31, May 8, July 23, July 28 and Sept. 28, 1928.
Installation for sintering fine ores. H. G. Torulf. No. 137,261. Jan. 19, 1928; in Great Britain Jan. 21, 1928.
Process for making a very hard alloy. W. Schrobsdorff. No. 137,262. Aug. 10, 1927; in Germany Aug. 12, 1926.
Metal foil. American Machine & Foundry Co. No. 137,263. June 1, 1928.
Process and apparatus for smelting oolitic granules from minette or similar fine ores or ore slimes. P. Gredt. No. 137,264. June 14, 1928.
Process for the production of potassium from potassium fluoride. I. G. Farbenindustrie A. G. No. 137,265. July 13, 1928; in Germany Aug. 5, 1927.
Inalterable white alloy. C. Philippossian. No. 136,266. Nov. 3, 1928.
Process for making molds for casting easily oxidizable metals. Le Magnesium Industriel and British Maxium, Ltd. No. 137,267. Mar. 12, 1928; in France Mar. 18, 1927.
Electrode for applying metal by the arc welding method. The Quasi-Arc Co., Ltd. No. 137,268. Jan. 22, 1929.
Electric furnace electrode. Soc. Electrométallurgique de Montricher. No. 137,325. May 29, 1928; in France Mar. 31, 1928.
Process and apparatus for melting gas- and oxide-poor iron alloys for foundry purposes. C. Brackelsberg. No. 137,517. Feb. 7, 1929; in Germany Feb. 16 and June 4, 1928.
Electrode for arc welding or brazing and process for making the same. Alloy Welding Process, Ltd. No. 137,518. Dec. 3, 1928; in Great Britain Dec. 13, 1927.
Method and means for obtaining a fine pointed flame with the electric arc. Presslicht Patent-Verwertungs G.m.b.H. No. 137,519. Mar. 4, 1929.
Method and means for operating ironless induction furnaces. Allgemeine Elektricitäts Gesellschaft. No. 137,585. Feb. 20, 1929; in Germany Feb. 21, 1928.
Welding and cutting burner. Autogen Endress A.G. No. 137,586. Nov. 17, 1928.
Process for coating metal with a metallic, non-rusting, acid-proof protective layer, and protective layer produced by this process. American Machine and Foundry Co. No. 137,750. July 7, 1928.
Apparatus for cleaning metal parts, particularly machine parts. Hahn and Kolb. No. 137,751. Dec. 17, 1928; in Germany Apr. 28 and June 22, 1928.
Alloy for tools, etc. W. Schrobsdorff. No. 137,805. July 7, 1927; in Germany July 21, 1926.
Process for making aluminum alloys having a high silicon content. Th. Goldschmidt A. G. No. 137,806. July 8, 1926; in Germany July 10, 1925.
Process for homogenizing alloys of lead with alkali or alkaline-earth metals. I. G. Farbenindustrie A.G. No. 137,807. Dec. 31, 1928.
Apparatus for electric arc welding. A. G. Brown, Boveri & Cie. No. 137,808. Feb. 19, 1929; in Germany Feb. 25, 1928.
Electric heating element. P. A. Klinge and O. E. Borgstrom. No. 137,874. Jan. 26, 1929.
System for operating electric induction furnaces not having a closed iron circuit. Allmänna Svenska Elektrisk AB. No. 137,875. Apr. 19, 1929; in Sweden Apr. 21, 1928.
Highly fire-resistant alloy of iron, nickel, chromium, silicon and carbon. Fried. Krupp A. G. No. 138,064. Mar. 22, 1928; in Germany Mar. 28 and Nov. 30, 1927.
Metal for welding aluminum and process for preparing it. P. Odam. No. 138,065. Nov. 14, 1928; in France Nov. 21, 1927.
Process for soldering iron and steel parts. F. von Wurstemburger. No. 138,067. Mar. 26, 1929.
Electric soldering and welding apparatus for thin-walled tubing and the like, having lap joints. V. Dolffs and Helle. No. 138,068. Mar. 11, 1929.
Process for making articles from metallic powder. I. G. Farbenindustrie A.G. No. 138,072. Mar. 1, 1929; in Germany Mar. 26, 1928.
Method of starting up salt-bath furnaces. Siemens-Schuckertwerke G.m.b.H. No. 138,138. Mar. 11, 1929; in Germany Mar. 21, Apr. 21, 1928, Feb. 11, and Mar. 4, 1929.
Electromagnetically controlled hydraulic regulator for arc furnaces. L. Tagliaferri. No. 138,139. Mar. 20, 1929.
Process for preventing corrosion of amalgamated electrodes. I. G. Farbenindustrie A.G. No. 138,309. May 23, 1928; in Germany July 11, 1927.
Electrolytic chromium plating process. Soc. Nouvelle de l'Orfevrerie d'Ercuis. No. 138,329. Dec. 17, 1928; in France Jan. 12, 1928.
Process for roasting sulphide ores and other materials containing sulphur. Säurefabrik Schweizerhall. No. 138,363. Jan. 19, 1929.
Heat-resistant and acid-proof alloy of iron, chromium, aluminum and copper. Oesterreichische Schmidtstahlwerke A.G. No. 138,364. Jan. 26, 1929; in Austria Jan. 28, 1928.
Process and apparatus for casting molten metals under pressure. R. H. V. Christiansen. No. 138,365. Feb. 18, 1929; in Denmark Feb. 29, 1928; in France Oct. 9, 1928.
Corrosion-resistant objects of steel or cast iron, and process for making these objects. Aubert and Duval Frères. No. 138,371. Jan. 23, 1929; in Germany Jan. 26, 1928.
Method of operating high-frequency furnaces. Allgemeine Elektricitäts Gesellschaft. No. 138,432. Dec. 5, 1928; in Germany Dec. 7, 1927.
Process for providing a ceramic object with an adherent metallic coating. Westinghouse Electric and Manufacturing Co. No. 138,610. July 25, 1928; in the United States July 30, 1927.
Process for making objects of corrosion-resistant alloy steel and objects obtained by this process. Thos. Firth and Son, Ltd. No. 138,647. Dec. 27, 1928; in Great Britain Dec. 31, 1927.
Alloy steel. Deutsche Edelstahlwerke A.G. No. 138,648. Feb. 1, 1929; in Germany May 8, 1928.
Electric welding burner. "Elin" A.G. für elektrische Industrie. No. 138,649. Nov. 29, 1928; in Austria Nov. 30, 1927.
Process for case-hardening metals. P. W. Shimer and E. B. Shimer. No. 138,654. June 18, 1928; in the United States June 22, 1927.
Process and apparatus for heat-treating metals or other substances. U. Infra. No. 138,655. Feb. 15, 1929; in France Feb. 20, 1928.
Annealing furnace having a sealing trough. Siemens-Schuckertwerke A.G. No. 138,656. Mar. 4, 1929; in Germany Mar. 14, 1928.
Means for preheating and cooling annealing pots. Vereinigte Drahtwerke A.G. No. 138,657. May 10, 1929.
Structural steel having a low A_1 point, a high yield point and a good degree of toughness. Vereinigte Stahlwerke A.G. No. 138,938. Feb. 25, 1929; in Germany Mar. 10, 1928.
Aluminum casting alloy. Aluminium Industrie A.G. No. 138,939. Apr. 30, 1929; in Germany July 4, 1928.
Crucible for making pipes by the centrifugal process. Soc. d'Expansion Technique. No. 138,940. Mar. 27, 1929; in France Apr. 20, 1928.
Process for degassing light metals. Vereinigte Aluminiumwerke A.G. No. 138,941. May 8, 1929; in Germany June 12, 1928.
Process for welding or caulking defective places in castings and objects of all sorts. M. U. Schoop. No. 138,942. Feb. 18, 1929.
Process for welding metals and alloys. I. G. Farbenindustrie A. G. No. 138,943. Feb. 8, 1929; in Germany Feb. 13, 1928.
Process and device for treating the surface of a metallic body. E. G. Herbert. No. 138,950. Aug. 20, 1928; in Great Britain Aug. 29, 1927.